ESEARCH TO MEET U.S. ND WORLD FOOD NEEDS

VOLUME I

EPORT OF A WORKING CONFERENCE

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RESEARCH TO MEET U.S. AND WORLD FOOD NEEDS

Report of a Working Conference
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VOLUME I

PREFACE

The compelling need to provide adequate and nutritious food for the people of the United States and of the world accentuates the importance of scientific research on food supply and consumption. The power of effectively disseminated research results to increase the productivity and efficiency of food systems is beyond question. With this power comes the responsibility to use it to the best possible advantage.

Such thoughts were in the minds of delegates to the 1974 World Food Conference when they declared:

> All governments should accept the removal of the scourge of hunger and malnutrition, which at present afflicts many millions of human beings, as the objective of the international community as a whole, and accept the goal that within a decade no child will go to bed hungry, that no family will fear for its next day's bread, and that no human being's future capacities will be stunted by malnutrition.

That goal is idealistic, but efforts to achieve it are both practical and imperative. The power of research, the responsibility associated with it, and the growing need for food require that research resources be focused on the most pressing problems.

The value of agricultural research and technology development has been demonstrated by recent history. In this Nation, since 1950: Crop production per acre has risen by 45 percent. Farm production per hour of labor has more than doubled. The number of people supplied by each farm worker has risen from 15 to 52. The acreage harvested per consumer has been reduced by nearly one-half.

Despite these accomplishments, today's need for new research findings in the agricultural and consumer sciences is no less pressing than it was a quarter of a century ago. It is even more urgent because of the expanding need for food in the face of diminishing or more costly resources. Furthermore, agricultural science and technology have only begun to be applied in many food deficit countries where hunger and malnutrition are widespread.

In addition, for a number of reasons--including the vastly more complex societal problems that challenge us today and the great and growing competition for public funds--it is becoming ever more crucial that priorities be established to enable our food research effort to concentrate on the most important problems that confront us now and in the foreseeable future.

Nationwide agricultural research planning of this kind is a responsibility of the Agricultural Research Policy Advisory Committee (ARPAC). ARPAC serves as an advisor to both branches of publicly supported agricultural research in the United States--the U.S. Department of Agriculture and, through the National Association of State Universities and Land-Grant Colleges, the land-grant universities and colleges.

Accordingly, in 1975, ARPAC initiated and convened a national Working Conference on Research to Meet U.S. and World Food Needs. The findings of that Conference, summarized in this report, will be of value to everyone who makes or carries out policy affecting agricultural research--legislators, administrators, and scientists--as well as to members of the public concerned about food--one of the overriding issues of our time.

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Co-Chairman, ARPAC

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Chapter 1

INTRODUCTION

For many decades mounting food production in the United States, culminating in the spectacular increases of the 1950's and early 1960's, resulted in domestic surpluses. These kept food prices relatively low, and public concern focused on the problem of managing the surplus (see Chapter 5, Volume II, Public Food Policy).

Today, public concern is focused on more ominous problems: Domestic and worldwide shortages of some commodities. Higher consumer prices. Unstable farm prices. And very recently, a study by the Board on Agriculture and Renewable Resources of the National Academy of Sciences found "disturbing exceptions" in the general pattern of continued increase in the efficiency of agricultural production (1).

As a result of these trends, the public and the scientific community share even greater concern over the ability of this country's agriculture to adequately supply domestic needs and to help other countries meet their food requirements.

"Adequate domestic supply" means enough nutrients to ensure health and well-being--a particular problem for less affluent citizens of the United States--and it raises a question of economics: How much of the household income must go for food? In any case, the level of output from crops and livestock and the effectiveness of processing and marketing are crucial factors.

Helping other countries meet their food requirements means not only providing food aid when shortage or disaster threaten but also putting agricultural science to work to increase and improve food supplies, especially in poor food deficit countries.

The outlook for the world during the next decade, discussed in detail in Chapter 4, Volume II, has two contrasting aspects:

- On a worldwide basis, projections of food supply and demand balance reasonably well, assuming that (1) world population grows no more than 2 percent yearly, and (2) crop output continues upward as a result of steadily improving technology and reasonably normal weather patterns.

- On a regional basis, however, it is very likely that serious deficits will appear in some regions (primarily heavily populated developing countries) while surpluses exist in others (primarily North America).

After 1985, the potential for variation in food supply and demand is much greater and the indicators are much less certain.

THE WORKING CONFERENCE

Against this background, the Agricultural Research Policy Advisory Committee (ARPAC) convened a national working conference to identify the most important problems requiring research during the next 10 to 15 years that affect the capacity of the United States to increase and improve domestic and world food supplies. The Conference was held in Kansas City, Missouri, on July 9-11, 1975.

Those who took part were:

- 167 delegates representing the wide-ranging needs of those who use or are affected by research results related to food.

- 215 other participants. These included research, extension, and university administrators; government agency administrators; individual researchers; farmers; representatives of agribusiness, and others.

- Members of the public and the press.

The first task of the Conference was to identify food-related problems requiring research. The second was to judge their relative importance. The Conference did not attempt to suggest research approaches for solving the problems or to recommend funding or organizational changes.

THE POPULATION PROBLEM

The planners of the Conference were aware that the future welfare of mankind depends on achieving a favorable balance between food supply and population growth. Nevertheless, the problem of population growth was omitted from the Conference agenda for two reasons:

- No currently proposed population control measures will result in enough food for everyone without an all-out effort to provide more food. Without such an effort, even the most optimistic proposals for population control would result, at best, in an increase of the proportion of people with an adequate diet. There still would not be enough for all. Therefore, any chance of achieving a significant breakthrough in eliminating global hunger depends on simultaneous effort to solve both problems--population control and food production.

- Food supply and population control are both extremely broad subjects. Problems will be better identified and planning will be focused more effectively if each is treated separately. It is important, of course, that interrelations between the two problems be taken into account.

SELECTION OF DELEGATES

Obviously, the deliberations of any group--including this conference--reflect the background and interests of its members. Recognizing this as a potential source of bias, the planners took special care to devise a delegate selection process that would bring about a balanced representation of groups and organizations with interests in food supply and consumption.

The procedures in delegate selection were to:

- Identify agencies or organizations with food interests that were national in character insofar as possible.

- Achieve a balance among groups such as consumers, nutritionists, farmers and farm organizations, agricultural and food industries, marketing firms, conservation groups, labor unions, government agencies, international development organizations, scientists, and others.

- Request that these organizations name their own delegates.

- Distribute the delegates among some 16 work groups at the conference so that each included an appropriate representation of interests.

Execution of these procedures was imperfect because of late cancellations and failure of some organizations to send delegates. Nevertheless, the overall balance of delegate interests among work groups and in the Conference was within reasonable limits. The names of the 167 delegates and the 215 other participants with their affiliations are listed in the Appendix. The numerical distribution of delegates by interest groups was as follows:

	Number of delegates attending
Consumer needs	12
Conservation and environment	6
Crop and livestock production	42
Food processing and marketing	33
Food regulation	4
Human resources and rural development	7
International development	10
Nutrition and food service	11
Production inputs	23
University-USDA research and extension personnel	19
	167

In addition to delegates, the other participants at the Conference also suggested research needs and participated in the rating procedure. In the following chapters, their evaluations are reported separately.

CONFERENCE PROCEDURES

This report is a result of the concern, the effort, and the decisions of the delegates and other participants in the Conference. The Conference procedures and other sources of input to the Conference and to this report were as follows:

Delegates and other participants in the Conference were asked first to suggest and to evaluate specific research needs or problems within the 49 research need areas listed in Table 1.1.

Identifying and assigning priorities to individual problems requires technical judgments based largely on specialized knowledge. Therefore, for this part of the Conference, delegates were divided according to their interest and expertise into 16 work groups, also listed in Table 1.1. Each group was concerned with no more than four or five related areas and with identifying and evaluating the most pressing needs or problems within those areas. Results are given in detail in Chapter 3.

Later in the Conference, delegates and other participants were asked to rate importance of the various research need areas--in other words, to make social judgments that would reflect the overall national interest. For example, they rated the need for research on human nutrient requirements as well as the need for research on soybean production. (Incidentally, both of those areas of research need were rated very high.) Results of these evaluations are given in Chapter 2.

To help in making their decisions, delegates and other participants had at hand several sources of information:

- Detailed situation statements on the various research need areas. This information appears in Chapter 3.

- A list of specific research needs or problems suggested by more than 700 agricultural researchers, extension personnel, and other scientists within the United States. These were intensively reviewed by several dozen scientists and administrators during a Pre-Conference Review in Beltsville, Maryland, in May 1975. These research needs were provided as suggestions to delegates and other participants. As it turned out, about 55 percent of the specific research needs identified as important by the Conference delegates were identical or very similar

to those suggested earlier by the scientists. The problems selected by the scientists are shown, in addition to those by delegates, in Chapter 3.

- Background information on the world food situation, on agricultural and food policies of the United States, and on the U.S. agricultural research establishment. This material, with some additions provided by speakers at the Conference, appears in Volume II of this report.

In addition to the formal rating of research needs, delegates and other participants also expressed concern about communication in the decisionmaking process. By voice vote, they asked for more effective communication of ideas in order to encourage realization "by governments everywhere that investment in agricultural research, development, and technology transfer is essential to the survival of all peoples and cultures on earth."

REFERENCE

(1) National Academy of Sciences.
1975. Agricultural Production Efficiency. Washington, D.C.

Table 1.1 Work Groups and Research Need Areas.

Work Group	Research Need Area
1. Human Nutrition	1.1 Nutrition Requirements 1.2 Nutrient Composition 1.3 Food Consumption 1.4 Delivery Systems: Education 1.5 Delivery Systems: Noneducation and Food Programs
2. Food Technology and Safety	2.1 Food Technology 2.2 Nonconventional Food Sources 2.3 Food Safety
3. Natural Resources	3.1 Land 3.2 Water 3.3 Weather and Climate 3.4 Energy
4. Cereals	4.1 Wheat 4.2 Rice 4.3 Corn 4.4 Grain Sorghum 4.5 Barley, Oats, and Rye
5. Oil Crops and Sugar	5.1 Soybeans 5.2 Cottonseed 5.3 Peanuts 5.4 Sunflower, Safflower, and Other Oilseeds 5.5 Sugar
6. Vegetables, Potatoes, Dry Beans, and Peas	6.1 Vegetable Crops 6.2 Potatoes 6.3 Dry Beans and Peas
7. Fruits, Nuts, and Bees	7.1 Fruits and Nuts 7.2 Bees and Other Pollinating Insects
8. Forage, Pasture, and Range	8.1 Harvested Forages and Seed Production 8.2 Permanent, Rotation, and Irrigated Pastures 8.3 Range

Table 1.1 Work Groups and Research Need Areas. (continued)

Work Group	Research Need Area
9. Beef, Pork, Lamb and Mutton, and Other Animal Products	9.1 Beef 9.2 Pork 9.3 Lamb and Mutton 9.4 Other Animal Products
10. Dairy, Poultry, and Aquatic Food Sources	10.1 Dairy 10.2 Poultry 10.3 Aquatic Food Sources
11. Human Resources and Social Institutions	11.1 Human Resources 11.2 Social Institutions
12. Marketing Systems	12.0 Marketing Systems
13. Production Inputs and Systems	13.1 Production Inputs and Services 13.2 Production Systems
14. Public Policy and Finance	14.1 Public Policy: Domestic 14.2 Public Policy: International 14.3 Finance
15. International Development	15.1 Food Production Technology and Resource Management 15.2 Food Quality and Distribution 15.3 Economic, Political, and Insititutional Aspects of Technology and Research
16. Work Groups 6,7, and 8 Combined	16.0 Basic Problems of Plant Growth and Reproduction

Chapter 2

AREAS OF RESEARCH NEED

The task of the Conference, as determined by ARPAC, was to identify problems requiring research that are crucial to increasing and improving United States and world food supplies.

Two distinct levels of decisionmaking were needed for that task. One can be considered a social judgment: Identification of the general areas requiring research to assure abundance, quality, and efficient distribution of food for human needs. The other is a more technical judgment: Identification of the most important specific problems within each area. Both types of research-planning decisions are needed for efficient use of scientific talent, facilities, and financial resources.

As described in Chapter 1, delegates and other participants at the Conference participated in both decisionmaking levels. Assembled in plenary session, they identified broad areas of research needs. In work groups, they identified technical problems.

This chapter of the Conference report is concerned with the social judgments--the broad areas of research need--and with certain "most important" individual problems. Detailed lists of problems and their assigned priorities within 49 research need areas are in the following chapter.

DELEGATES' RATING OF NEED AREAS

Three broad categories of research need areas were reviewed by the Conference:

1. Human needs for food--such areas as nutrient requirements for people of different ages and activity levels; the capability of food supplies to meet these requirements; patterns of food consumption by different groups; educational and other information-delivery programs to improve nutrition.

2. Organization of resources to provide food--human resources and social institutions; public policy, international development; finances; various inputs to production, processing, and marketing systems.

3. Management of resources to provide food--land, water, climate, and energy; plant and animal commodities.

Table 2.1 shows these three categories with the 49 research need areas from Chapter 1. The table further breaks down those need areas involving crops and livestock. It lists "production," "marketing and processing," and "consumer needs" for each commodity. Delegates to the Conference considered each of these crop and livestock subareas separately. Hence, a total of 89 research need areas and subareas was rated.

Delegates judged the importance of research need areas and subareas according to this criterion:

> "The importance of the research need area or subarea to the United States as a means of increasing and improving domestic and world food supplies."

The following scale was used:

Utmost Importance	= 5
Major Importance	= 4
Important	= 3

Average delegate ratings of individual research need areas are arranged according to subject matter areas in Table 2.1. The same figures are shown in descending order of rating in Table 2.2. The overall average rating of all need areas was 3.89.

In these tables, a high rating indicates that a particular food research area was considered very important to broad national and international interests. However, areas with lower priorities also are important. They, in fact, may be essential to certain commodities or certain regions of the United States. This is consistent with the multifaceted nature of the complex problem of providing food supplies. It would be a mistake to conclude that areas with lower ratings necessarily do not deserve continued research support.

Among the three major categories, "Organization of Resources" had the highest average rating (4.17). Statistically, this was not significantly greater than "Human Needs" (4.09) but was significantly greater than the average rating for "Management of Resources (3.83). Statistical comparisons of the three subareas for commodities show that the delegates rated production problems significantly higher than problems of either marketing-processing or consumer needs. Average ratings of the latter two did not differ significantly.

Table 2.1. Research Need Areas and Average Ratings. (Numbers in parentheses identify need areas as listed in Table 1.1 and elsewhere.)

	Average rating
I. HUMAN NEEDS FOR FOOD	
Nutrient requirements (1.1)	4.45
Nutrient composition (1.2)	4.16
Food consumption (1.3)	3.83
Delivery systems: Education (1.4)	4.16
Delivery systems: Noneducation and food programs (1.5)	3.92
Food technology (2.1)	4.28
Nonconventional food sources (2.2)	3.78
Food safety (2.3)	4.19
II. ORGANIZATION OF RESOURCES TO PROVIDE FOOD	
Human resources (11.1)	4.06
Social institutions (11.2)	3.90
Public policy: Domestic (14.1)	4.31
Public policy: International (14.2)	4.28
Finance (14.3)	4.07
International development: Food production technology and resource management (15.1)	4.43
International development: Food quality and distribution (15.2)	4.12
International development: Economical, political, and institutional aspects of technology and resources (15.3)	4.02
Production inputs and services (13.1)	4.43
Production systems (13.2)	4.27
Marketing systems (12.0)	4.04
III. MANAGEMENT OF RESOURCES TO PROVIDE FOOD	
Land (3.1)	4.42
Water (3.2)	4.53
Weather and climate (3.3)	4.06
Energy (3.4)	4.73
Basic problems in plant growth and reproduction (16.0)	4.51
Wheat: Production (4.1P)	4.32
Wheat: Marketing and processing (4.1M)	3.75
Wheat: Consumer needs (4.1C)	3.73

Table 2.1 (continued)

	Average rating
III: MANAGEMENT OF RESOURCES TO PROVIDE FOOD (continued)	
Rice: Production (4.2P)	4.00
Rice: Marketing and processing (4.2M)	3.48
Corn: Production (4.3P)	4.35
Corn: Marketing and processing (4.3M)	3.93
Corn: Consumer needs (4.3C)	3.83
Grain sorghum: Production (4.4P)	3.95
Grain sorghum: Marketing and processing (4.4M)	3.55
Barley, oats, and rye: Production (4.5P)	3.66
Barley, oats, and rye: Marketing and processing (4.5M)	3.22
Soybeans: Production (5.1P)	4.58
Soybeans: Marketing and processing (5.1M)	3.68
Soybeans: Consumer needs (5.1C)	4.07
Cottonseed: Production (5.2P)	3.67
Cottonseed: Marketing and processing (5.2M)	3.37
Cottonseed: Consumer needs (5.2C)	3.46
Peanuts: Production (5.3P)	3.58
Peanuts: Marketing and processing (5.3M)	3.62
Peanuts: Consumer needs (5.3C)	3.51
Other oilseeds: Production (5.4P)	3.63
Other oilseeds: Marketing and processing (5.4M)	3.33
Other oilseeds: Consumer needs (5.4C)	3.53
Sugar: Production (5.5P)	3.68
Sugar: Marketing and processing (5.5M)	3.41
Sugar: Consumer needs (5.5C)	3.51
Vegetable crops: Production (6.1P)	4.31
Vegetable crops: Marketing and processing (6.1M)	3.89
Vegetable crops: Consumer needs (6.1C)	3.78
Potatoes: Production (6.2P)	3.96
Potatoes: Marketing and processing (6.2M)	3.55
Potatoes: Consumer needs (6.2C)	3.26
Dry beans and peas: Production (6.3P)	4.08
Dry beans and peas: Marketing and processing (6.3M)	3.53
Dry beans and peas: Consumer needs (6.3C)	3.48
Fruits and nuts: Production (7.1P)	4.10
Fruits and nuts: Marketing and processing (7.1M)	3.76
Fruits and nuts: Consumer needs (7.1C)	3.57
Bees and other pollinating insects: Production (7.2P)	3.88
Bees and other pollinating insects: Marketing and processing (7.2M)	3.30
Bees and other pollinating insects: Consumer needs(7.2C)	3.39
Harvested forages and seed production:Production (8.1P)	4.24

Table 2.1 (continued)

	Average rating
III. MANAGEMENT OF RESOURCES TO PROVIDE FOOD (continued)	
Permanent, rotation, and irrigated pastures: Production (8.2P)	3.99
Range: Production (8.3P)	3.98
Beef: Production (9.1P)	4.31
Beef: Marketing and processing (9.1M)	3.88
Beef: Consumer needs (9.1C)	3.60
Pork: Production (9.2P)	4.11
Pork: Marketing and processing (9.2M)	3.70
Pork: Consumer needs (9.2C)	3.56
Lamb and mutton: Production (9.3P)	3.73
Lamb and mutton: Marketing and processing (9.3M)	3.39
Lamb and mutton: Consumer needs (9.3C)	3.41
Other animal products: Production (9.4C)	3.49
Other animal products: Marketing and processing (9.4M)	3.35
Dairy: Production (10.1P)	4.32
Dairy: Marketing and processing (10.1M)	3.79
Dairy: Consumer needs (10.1C)	3.84
Poultry: Production (10.2P)	4.12
Poultry: Marketing and processing (10.2M)	3.78
Pountry: Consumer needs (10.2C)	3.81
Aquatic food sources: Production (10.3P)	4.29
Aquatic food sources: Marketing and processing (10.3M)	3.99
Aquatic food sources: Consumer needs (10.3C)	3.90

Table 2.2. Research Need Areas in Order of Rating by Delegates. (Numbers in parentheses identify need areas as listed in Table 1.1 and elsewhere.)

	Average rating
Energy (3.4)	4.73
Soybeans: Production (5.1P)	4.58
Water (3.2)	4.53
Basic problems in plant growth and reproduction (16.0)	4.51
Nutrient requirements (1.1)	4.45
Production inputs and services (13.1)	4.43
International development: Food production Technology and resource management (15.1)	4.43
Land (3.1)	4.42
Corn: Production (4.3P)	4.35
Wheat: Production (4.1P)	4.32
Dairy: Production (10.1P)	4.32
Beef: Production (9.1P)	4.31
Public policy: Domestic (14.1)	4.31
Vegetable crops: Production (6.1P)	4.31
Aquatic food sources: Production (10.3P)	4.29
Public policy: International (14.2)	4.28
Food technology (2.1)	4.28
Production systems (13.2)	4.27
Harvested forages and seed production: Production (8.1P)	4.24
Food safety (2.3)	4.19
Delivery systems: Education (1.4)	4.16
Nutrient composition (1.2)	4.16
International development: Food quality and distribution (15.2)	4.12
Poultry: Production (10.2P)	4.12
Pork: Production (9.2P)	4.11
Fruits and nuts: Production (7.1P)	4.10
Dry beans and peas: Production (6.3P)	4.08
Finance (14.3)	4.07
Soybeans: Consumer needs (5.1C)	4.07
Human resources (11.1)	4.06
Weather and climate (3.3)	4.06
Marketing systems (12.0)	4.04
International development: Economical, political, and institutional aspects of technology and resources (15.3)	4.02
Rice: Production (4.2P)	4.00
Permanent, rotation, and irrigation pastures:Production(8.2P)	3.99

Table 2.2 (continued)

	Average rating
Aquatic food sources: Marketing and processing (10.3M)	3.99
Range: Production (8.3P)	3.98
Potatoes: Production (6.2P)	3.96
Grain sorghum: Production (4.4P)	3.95
Corn: Marketing and processing (4.3M)	3.93
Delivery systems: Noneducation and food programs (1.5)	3.92
Social institutions (11.2)	3.90
Aquatic food sources: Consumer needs (10.3C)	3.90
Vegetable crops: Marketing and processing (6.1M)	3.89
Beef: Marketing and processing (9.1M)	3.88
Bees and other pollinating insects: Production (7.2P)	3.88
Dairy: Consumer needs (10.1C)	3.84
Food consumption (1.3)	3.83
Corn: Consumer needs (4.3C)	3.83
Poultry: Consumer needs (10.2C)	3.81
Dairy: Marketing and processing (10.1M)	3.79
Poultry: Marketing and processing (10.2M)	3.78
Nonconventional food sources (2.2)	3.78
Vegetable crops: Consumer needs (6.1C)	3.78
Fruits and nuts: Marketing and processing (7.1M)	3.76
Wheat: Marketing and processing (4.1M)	3.75
Wheat: Consumer needs (4.1C)	3.73
Lamb and mutton: Production (9.3P)	3.73
Pork: Marketing and processing (9.2M)	3.70
Sugar: Production (5.5P)	3.68
Soybeans: Marketing and processing (5.1M)	3.68
Cottonseed: Production (5.2P)	3.67
Barley, oats, and rye: Production (4.5P)	3.66
Other oilseeds: Production (5.4P)	3.63
Peanuts: Marketing and processing (5.3M)	3.62
Beef: Consumer needs (9.1C)	3.60
Peanuts: Production (5.3P)	3.58
Fruits and nuts: Consumer needs (7.1C)	3.57
Pork: Consumer needs (9.2C)	3.56
Grain sorghum: Marketing and processing (4.4M)	3.55
Potatoes: Marketing and processing (6.2M)	3.55
Dry beans and peas: Marketing and processing (6.3M)	3.53
Other oilseeds: Consumer needs (5.4C)	3.53
Sugar: Consumer needs (5.5C)	3.51
Peanuts: Consumer needs (5.3C)	3.51
Other animal products: Production (9.4P)	3.49
Dry beans and peas: Consumer needs (6.3C)	3.48
Rice: Marketing and processing (4.2M)	3.48
Cottonseed: Consumer needs (5.2C)	3.46
Lamb and mutton: Consumer needs (9.3C)	3.41

Table 2.2 (continued)

	Average rating
Sugar: Marketing and processing (5.5M)	3.41
Lamb and mutton: Marketing and processing (9.3M)	3.39
Bees and other pollinating insects: Consumer needs (7.2C)	3.39
Cottonseed: Marketing and processing (5.2M)	3.37
Other animal products: Marketing and processing (9.4M)	3.35
Other oilseeds: Marketing and processing (5.4M)	3.33
Bees and other pollinating insects: Marketing and processing (7.2M)	3.30
Potatoes: Consumer needs (6.2C)	3.26
Barley, oats, and rye: Marketing and processing (4.5M)	3.22

SUMMARY

Human needs	4.09
Organization of resources	4.17
Management of resources:	3.83
Natural resources	4.43
All commodities:	
Production	4.01
Marketing and processing	3.61
Consumer needs	3.58

PARTICIPANT RATINGS

The above findings are based entirely on ratings by the delegates. In addition, however, other participants at the Conference had an opportunity to rate the areas and subareas and the individual problems.

An average of 90 other participants rated each area and subarea. The results from these ratings show a very high concordance with the ratings by the delegates.

TOP-RANKED NEED AREAS AND MOST IMPORTANT PROBLEMS

Eighty-nine research need areas and 1011 potentially researchable problems were considered by delegates at the Conference and judged important enough to list in their reports. Nearly as many additional research needs were suggested, considered, and eliminated during work group discussions.

As will be described in detail in Chapter 3, delegates developed priority ratings for individual problems within each research need area. Based on these ratings, the 1011 were selected as important. Also as described above, delegates rated need areas and subareas in accordance with their social importance. However, a significant question remains: Of all problems in all areas, which can reasonably be described as most important?

The remainder of this chapter is concerned with answering that question. This is done by:

- Presenting a summary of the high priority needs for areas and subareas in the top half of the list--those with a rating of 3.90 and above.

- Selecting the most important individual research problems by a rating index that takes into account both the area rating and the relative rating of the problem within its area.*

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*The selection procedures consisted of: (1) computing the ratio of each problem ratings to the average of all problem ratings in its area or subarea; (2) multiplying this ratio by the area or subarea rating; (3) ranking all problems in accordance with this rating index; and (4) selecting the highest 10 percent.

This procedure resulted in a list of 101 problems that can logically be designated *most important*. These problems represent those research needs that should receive special consideration by research administrators, planners, and individual scientists. Many of the other problems identified as important at the Conference also must be solved if U.S. and world food needs are to be met, but the 101 deserve at least first consideration in program formulation and cooperative planning. Of course some of the *most important* problems may serve as central needs around which other problems can be evaluated.

Analysis of the *most important* problems reveals several points:

- All their adjusted ratings are sufficiently close that they can be considered as a single group from the standpoint of importance. They are presented here in logical groupings within need areas, not in order of priority.

- More than 40 percent of the problems concern food production, primarily the needs to increase yields and provide food to consumers at least cost. However, they are narrowly focused on a few major crops and animals.

- An additional 26 percent of the problems are in the areas of natural resource use and conservation, including fuel sources and land and water use.

- Other sets of *most important* problems involve human nutrition, a variety of public policy issues, and certain aspects of international development.

In the following pages, the 101 *most important* problem statements appear in italic type. They are listed within the appropriate research need areas.

The selection of the 101 problems was based entirely on delegate ratings. However, more than 70 percent of these problems also were identified as important by research and extension scientists, as described in Chapter 1. In these cases, an "S" in parentheses appears after the problem statement. If the other participants at the Conference also selected one of these problems as important, a "P" is shown.

DISCUSSION OF RESULTS

Category I: Human Needs for Food

Nutrient requirements (1.1) Nutrient requirements for humans are defined either poorly or not at all; in fact, trace element

requirements are better known for some other animal species than for humans. Research methodology for studying human nutrition needs to be improved. Deficiencies and excess nutrition are problems for different age groups. Replacement of traditional foods by new protein sources and fabricated foods has altered food balances with very little knowledge of the nutritional consequences. This research need area was top ranked in the human needs category and fifth among all areas.

Most Important problems:

Identify differences in nutrient requirements according to age, sex, occupation, and varying stress conditions, particularly for high risk groups (pregnancy, lactation, infancy, adolescence, and aging). (SP)

Determine the best criteria for establishing nutrient requirements.

Determine interrelationships of nutrients and other food components that affect nutrient availability. (SP)

Determine the requirements for types and quantities of carbohydrates, including fiber required to maintain health and to prevent diseases associated with imbalanced intake. (SP)

Develop new techniques for assessing diets and for reporting the results on a U.S. and global basis. (SP) (This problem statement appears in Chapter 3 under need area 1.3 but also logically fits here.)

Nutrient composition (1.2) Accurate, up-to-date, and comprehensive information is needed on the composition of important foods, the effects of processing on nutritional value, and the biological availability of nutrients. Comprehensive standard reference tables on nutrient content are needed to estimate the nutritive value of food supplies and to plan diets, food distribution programs, and food production.

Most Important problems:

Devise a system to channel scientific findings and analytical data from private and public laboratories into a central, computerized nutrient data bank in a form that can be readily retrieved and disseminated. (SP)

Investigate factors affecting the biological availability of nutrients: (a) chemical form of nutrient, (b) interrelationships to other nutrients, (c) presence of inhibitors. (SP)

Investigate nutrient changes in foods that occur after harvest or slaughter and during processing and distribution. (SP)

Investigate the relationship between analytical values and biological availability. (SP)

Delivery systems: Education (1.4) Delegates emphasized the need to develop and evaluate alternative nutrition education programs if the diets of all consumers are to improve. Only a limited amount of research on food habits is conducted by universities and the USDA. Research is needed on factors which can change eating behavior and acceptance of particular foods, genetic and environmental influences on eating habits, and motivation for improving eating behavior.

Most Important problems:

Develop and evaluate alternative programs for nutrition education. (SP)

Develop and evaluate a media integrated campaign to combat food and nutrition misinformation in order to enable the public to make nutritionally sound food choices.

Delivery systems: Noneducation and food programs (1.5) Research could improve programs to meet food needs of special population groups--needy families, groups of children, the sick, the elderly, communities that require emergency relief, food stamp recipients.

Delegates believed there is a need to evaluate the effectiveness and efficiency of all existing food programs--domestic and overseas--and to preevaluate the potential effectiveness of any new programs.

(This research need area, as well as a number of those on the following pages, are ranked in the top 50 percent of all need areas but do not contain any of the problems selected by the rating index as *most important*.)

Food technology (2.1) This need area, rated second in this category, involves problems of improving processes for assembling, preserving, and storing food while keeping it safe, wholesome, and nutritious. Delegates also were concerned with the costs and energy requirements of food preservation and delivery systems, waste reduction and disposal, and improvement of food quality. Delegates indicated that although U.S. food quality and availability are very good, new food processing methods are needed to lower costs, further improve quality, and reduce adverse environmental effects.

Most Important problems:

Determine the social and economic feasibility and nutritive possibilities of new or improved foods and processes. (SP)

Search for new techniques to reduce the cost of sanitation methods during food processing, in order to lower expenditures of chemicals, water, and energy.

Develop methods and equipment to collect, treat, and dispose of food processing wastes; or to use them for food, feed, or byproducts. (SP) (Combines two very similar problems shown in Chapter 3. They were ranked 2 and 4.)

Develop low-energy systems and equipment for food processing plants, the food service operation, and storage and distribution--including the use of less energy intensive materials (fiber, paper, foil, plastic films) and including evaluation of the effects of the processing change on microbiology of the food to ensure that it is safe and suitable for the public. (SP) (Combines two very similar problems, one in this area and one in 3.4 Energy.)

Food safety (2.3) Both natural toxicants (those that are normal components of foodstuffs) and manmade toxicants (such as pesticides, metals, and preservatives) are important aspects of this research need area. Although the delegates recognized food preservatives as essential, it is not known whether some may constitute health hazards in the long run or under certain conditions of use.

Most Important problems:

Develop workable guidelines to determine the significance to human health of minute residues of chemical substances in all food products. (This problem, stated almost identically, appears in various research need area lists, particularly in crops and livestock.)

Determine methods of handling contaminants removal, detoxification, dilution, etc. (SP)

Category II: Organization of Resources to Provide Food

All 11 research need areas under this category were rated by the delegates in the top half of the list.

Human resources (11.1) In developed countries, technological changes in agriculture have drastically reduced labor needs. Most of the displaced people have been absorbed in expanding nonfarm activities, but the process frequently has been painful--and agriculture still has a labor problem. The U.S. farm labor problem probably could be eased if more were known about the effects of wage levels, community status and self-image, collective bargaining alternatives, and ways to provide nutrition and health education to farm workers. In developing countries, displaced farm people have moved to cities with very little employment opportunity. In these regions, the needs include improvement of human potential for alternate employment and extension services adapted to national situations.

Most Important problem:

Determine factors needed to provide farm labor supply, including both wage levels and other factors affecting the community status and self-image of farm workers. (SP)

Social institutions (11.2) The objective of this research need area is to help rural communities achieve social goals through their own planning and investments and to improve the effectiveness of their institutions. Issues include the family farm and factors that affect it, such as taxation and the entry of young people into farming; agricultural research institutions and how best to plan, conduct, and finance research; and techniques to aid local governments in analyzing their own problems.

Public policy: Domestic (14.1) Public policy signficantly influences U.S. agricultural production, processing, distribution, and consumption. Intelligent public decisions are possible if dependable information on the benefits and costs of carefully assessed alternatives is available. The objective of research on public policy is to provide this kind of information. Many of the problems emphasized by delegates deal with policy impact--that is, the future consequences of alternative policies. Important aspects of this research need area are strategies for food production and processing adapted to the impending depletion of

fossil fuels and the effects of various governmental interventions on the structure and organization of U.S. agriculture.

Most Important problems:

Develop strategies and techniques to accommodate American food production and processing practices to the impending exhaustion of fossil fuel supplies. (SP)

Determine the effects of tax, price, antitrust, land tenure regulation, and cooperative marketing policies, on the type of economic organization of agriculture that we will have in this country, e.g., a dispersed, competitive agriculture; an agriculture concentrated in the hands of nonfarm corporate firms; or a government-controlled agriculture.

Public policy: International (14.2) Agricultural policy actions today clearly have greater international effects than in the past. In this new environment, there is need to assess the interlocking effects of agricultural and trade policies of many nations. However, policy research on international aspects of agriculture is still in its infancy.

Most Important problems:

Evaluate alternate world food reserve policies designed to achieve varying degrees of price and supply stability. (SP)

Analyze the implications of alternative U.S. foreign technical and food assistance on income level and distribution and on employment in recipient countries. (SP)

Establish alternative world and regional scenarios of long range (beyond 1985) future resource use and production alternatives in light of various projections of population growth, development of new technology, potential of exhausted fossil fuels and other known energy supplies, including scarcities brought about by cartels.

Finance (14.3) Capital formation and financing have been major contributors to agricultural expansion. Increased productivity is associated with reduced or low-cost finance. However, agriculture in recent years has become increasingly vulnerable to market risks. Trends indicate increasing indebtedness in relation to assets. Internationalizing agricultural commodity markets and reduction of crop inventories have added to the financial risks.

Most Important problem:

Study the problem of intergenerational transfer of farm property and the effects of particular tax policies--such as estate and inheritance taxes--upon this process as a means of maintaining the family farm.

<u>International development: Food production technology and resource management (15.1)</u> The target is developing countries where food production has fallen behind requirements and where crop yields may be half or less of those in developed countries. The need is to discover how to encourage yield-increasing technologies--land and water management, fertilization, crop protection, and others--designed for use on small land holdings, with limited resources. Some of these improvements are possible simply by using practices developed elsewhere, but others require adapting the known technology to a new set of circumstances. Many, perhaps most, of the new biological technologies must be worked out on research stations or farms, country by country or region by region. This need area was rated seventh in importance among all areas.

Most Important problems:

Develop high-yielding varieties of important food legumes and other vegetables (including dry beans, soybeans, cowpeas, pigeonpeas, chickpeas, peanuts, lentils, and broadbeans) with high level of genetic resistance to insect and disease problems, giving attention to: (1) physiological and morphological constraints that limit yield of this group of food crops (including indeterminate flowering, rate of flower drop, and photosynthetic efficiency); (2) soybean varieties for the tropics and subtropics; and (3) nutritional content and naturally occurring toxicants. (SP)

Develop high-yielding varieties of cereals (including wheat, maize, rice, sorghum, millet, and barley) adapted to a wide range of environmental conditions and resistant to insect pests, diseases, and unfavorable soil conditions, with attention to nutritional content and naturally occurring toxicants. (SP)

Develop high-yielding varieties of important starch food staples (including potatoes, sweet potatoes, cassava, and yams) with attention to nutritional quality, disease and insect resistance, nutritional content, and naturally occurring toxicants. (SP)

Develop procedures to minimize high energy technology inputs while increasing crop, livestock, and poultry production through new genetic and management programs.

Develop improved farming systems with emphasis on the small farmer (may include a series or a combination of crops along with livestock). . (SP)

Develop improved soil and water management technology, particularly in relation to food production in the developing tropical countries. (SP)

Develop alternate or improved technologies for supply of plant nutrients including more effective and broadbased biological fixation of nitrogen and more appropriate chemical fertilizer technology for tropical soils and climate. (SP)

<u>International development: Food quality and distribution (15.2)</u> It is estimated that 460 million people in the world are malnourished. Women and children are the most vulnerable. One component of the problem involves nutrition standards and nutrition education; another is the internal distribution of food within countries. Failures in marketing systems often are linked to inadequate and costly transportation, inadequate storage, taxation, and restrictions on trade across national boundaries.

Most Important problem:

Determine standards for what constitutes a balanced diet for major age groups in developing regions and countries, taking into account energy, vitamin, mineral, and protein requirements. (SP)

<u>International development: Economic, political, and institutional aspects of technology and research (15.3)</u> This need area addresses the problem of extending technical assistance to food deficient areas of developing countries. Attitudes of people and their motivation to change are affected by economic, political, and institutional arrangements. The initiative for needed change rests with political leaders, researchers, and educators, business executives, labor leaders, farmers, and others--all of whom need research-based information. Within the United States, there is a need to develop policies for using domestic agricultural research resources on problems of developing countries and to develop better mechanisms for using U.S. research institutions in work overseas. Both at home and overseas, research could help provide the information needed to assess risks and potential benefits.

Most Important problem:

Assess the benefits and costs of importing versus domestically producing farm inputs such as fertilizer and machinery.

Production inputs and services (13.1) The objective here is to assure an adequate and stable supply of inputs, particularly of the two most important types--agricultural chemicals and farm equipment and supplies. Fertilizers are the primary chemical input in terms of tonnage and cost. This research need area was rated first in its category and sixth among all areas and subareas.

Most Important problems:

Analyze long-term sources of economical raw materials for fertilizers, pesticides, farm equipment, and other production inputs.

Develop nitrogen fertilizer production processes independent of natural gas or crude oil derivatives; concentrate on use of coat for ammonia production.

Investigate and develop new sources of energy for production inputs (solar power, wind power, tides, fusion, etc.). (SP)

Improve efficiency of photosynthesis that in turn will improve efficiency of all inputs--CO_2, water, or nutrient elements. (SP)

Production systems (13.2) Production systems research extends beyond the economics of farm output and embraces the physical, biological, economic, and engineering problems of agricultural production, as well as associated human and institutional factors. This area includes, for example, such research needs as identifying practical alternatives to conserve energy, developing alternative multiple-crop management systems, analyzing the impacts of taxes on production efficiency, and studying various forages as grain substitutes in beef production.

Most Important problem:

Identify practical energy-conserving alternatives for food production, including alternative cropping, harvesting, and storage systems.

Marketing systems (12.0) Rising food prices, shortages, and domestic nutrition problems have increased public concerns about the performance of the food marketing system. These concerns include waste, proliferation of products and services, nutrition versus service, and the inflexibility of mass marketing. Changes in marketing structure have raised questions about the system's competitiveness and efficiency, possible misuse of economic power, and whether price is based on supply and demand. Research could clarify these issues and spur improvements such as greater marketing efficiency through standardization and modularization of containers and packages and new price discovery techniques between buyers and sellers.

Category III: Management of Resources to Provide Food

Research need areas in this category encompass the physical and biological components of the food system--natural resources (land, water, weather and climate, and energy) and a variety of crops and livestock. Nine of the 12 top-ranked research need areas are in this category. Delegates rated three of the four natural resource areas among the top eight in importance. Among the crop need areas, a possibly significant pattern is the emphasis on plant breeding as a means of solving production problems.

Natural Resources

Land (3.1) Although the world presently is not short of potentially arable land, there are serious regional shortages. Also, land not now being cultivated is less productive, and poses serious development difficulties. Other aspects of this need area include the preserving of prime land, retaining the productivity of poorer land, developing classification systems based on land use potential, and other problems of public policy and technological development. As with water, problem statements in many crop need areas also reflect the need for development, management, and conservation of land.

Most Important problems:

Develop plans for retaining lands as agricultural or open space with emphasis on proper compensation for present owners.

Develop reduced-tillage practices that are economically feasible for use with a wide range of soil, climate, and crop conditions. (SP)

Evaluate the impact of wind and water erosion on long-term soil productivity and crop yields in relation to environmental quality. (S)

Water (3.2) The water resource issue was rated third in importance among all research need areas and subareas. Delegates viewed it primarily as a problem of efficiently utilizing present and potential supplies, with due consideration for other uses and for environmental quality. Research on both public policy and improved technology are important aspects of this need area. Work groups other than the one concerned with natural resources also listed water-related problems, such as water use in food processing and pollution from agricultural production practices.

Most Important problems:

Determine the most efficient combination of water and related land laws, water rights, and market mechanisms to develop, conserve, and efficiently utilize water supplies including ground water. (SP)

Determine impacts of Federal and State water quality legislation and administration on water development and food production. (SP)

Improve soil and water management to control erosion and sedimentation. (SP)

Determine timing and amounts of crop irrigation, considering crop variety, to more efficiently use water consistent with economic constraints, energy, and water quality. (SP)

Develop an improved system of environmental monitoring to detect problems such as those that have developed from PCB's, hexachlorobenzene, and other substances that have produced unexpected ill effects.

Make more efficient use of water and nutrients, putting these necessities near the plant at a location for most efficient utilization.

In the 17 Western States and in selected parts of the developing world, determine the costs, in terms of reduced yields or of measures necessary to maintain yields, of increased water salinity resulting from irrigation return flows.

Find ways to improve irrigation water storage and distribution systems in order to increase water use efficiency and control water quality. (SP)

Weather and climate (3.3) Land, weather, and climate determine both the location of agricultural activity and the potential level of agricultural production. Only limited areas of the world have optimum conditions. Consequently, most agricultural areas must be concerned with the adverse effects of too much or too little precipitation, temperature extremes, wind, hail, and combinations of these factors. Important research needs on weather and climate involve data collection to evaluate potential food production areas, improved crop use of carbon dioxide and solar energy, and prediction of effects on plant and soil microclimates. Establishment of a network to measure net radiation, soil moisture, and soil temperature was proposed.

Most Important problem:

Evaluate those areas where renewable resources can be optimally developed in relation to agriculture and food production.

Energy (3.4) The highest ranked of all research need areas was the energy problem in agriculture. It was defined largely as a need to improve the efficiency of energy utilization in the entire food process from farm to table and to develop substitutes for fossil fuels and mineral fertilizers.

The need to obtain substitutes for fossil fuels included development of nuclear sources, solar energy, and agricultural wastes.

Work groups identified important energy problems in 25 different research need areas, including all steps of the food system from manufacture of production inputs to food delivery programs. Other research problems involving energy are listed, for example, under Food technology (2.1) and Production inputs (13.1).

Most Important problems:

Evaluate the impact an energy tax or energy allocation system would have on food supplies. (S)

Develop methodologies to evaluate the impact on agricultural production of transferring water from irrigated agriculture to energy development. (S)

Determine the impact of varying levels of energy costs on the economic attractiveness of land-conserving technologies (ground water irrigation, heavy per acre use of fertilizers and pesticides) relative to land-using technologies (dry land farming, relatively light per acre use of fertilizers and pesticides).

Determine ways to recycle wastes. Destruction of all types of used products wastes our energy resources as well as contributes to environmental contamination.

Increase use of agricultural wastes and other sources of biomass as power and heat sources. (SP)

Develop uses of nuclear energy including fusion. (SP)

Develop and improve the technology and use of solar energy separately or in conjunction with other forms of energy for heat and power. (SP)

Increase heat storage efficiency and capacity to use waste heat. (SP)

Determine equipment performance requirements for energy conversion in order to provide satisfactory components for food systems. (S)

Identify agricultural production and processing practices that will allow for ready substitution of electric energy for operations now using nonrenewable resources. Determine the extent of such substitution, Statewise and nationally, so the electric energy industry can more adequately plan plant construction for food production, processing, and distribution 10 years hence.

Develop low-energy culture systems for food production and improved technology for small-scale agriculture. (S)

Increase use of renewable organic fertilizers and nitrogen fixation and more efficient use of nitrogen fertilizer. (SP)

Crops

Basic problems in plant growth and reproduction (16.0) Nearly all crop area statements reflected to some degree the importance of research on basic problems in plant growth and reproduction. Listed here are those not primarily commodity oriented. This research need area was rated fourth in importance among all areas

and subareas. It is dominated by interest in two fundamental plant processes--photosynthesis and biosynthesis of ammonia (nitrogen fixation)--as well as plant growth mechanisms.

Most Important problems:

Determine the fundamental mechanisms of photosynthesis in order to improve plant productivity.

Improve and develop nitrogen-fixing capacity in nonlegume plants. (SP)

Devise new methods and improve existing methods of plant breeding. (SP)

Develop techniques for cell culture, tissue culture, somatic hybridization, and related approaches for basic research in plant physiology and genetics.

Determine the basic mechanisms involved in plant growth regulator activity.

Develop techniques whereby germplasm of vegetatively propagated plants, particularly fruits, vegetables, and woody shrubs, may be maintained.

Wheat: Production (4.1) Wheat accounts for one fifth of the world's total caloric intake. About 10 percent of the world wheat crop is fed to livestock. The world food supply, therefore, depends heavily on wheat--of which the United States is a major producer and exporter. About half of the U.S. crop has been exported annually during the past 10 years. Eleven of the 20 top problems listed by delegates dealt with genetics and breeding. The susceptibility of wheat to diseases and insects and their ability to alter their own characteristics to overcome bred-in resistance demand constant vigilance by plant breeders.

Most Important problems:

Minimize genetic vulnerability to environmental stress, insects, diseases, nematodes, and weeds. (SP)

Develop genetic resistance to major diseases, nematodes, and insects. (SP)

Produce wheats better adapted to growing conditions, particularly via improved winter hardiness, drought tolerance, and seedling vigor. (SP)

Collect and maintain a stockpile of wheat germplasm so that new genetic combinations can be made. (SP)

<u>Rice: Production (4.2)</u> Rice is the most important food crop for about half of the world's people. It provides three-fourths of the total caloric intake for 1.9 million Asians and up to a third for 0.8 billion Africans and Latin Americans. More than 85 percent of the world rice output comes from noncommercial subsistence farming areas of Asia. Although the United States produces only about 1.5 percent of the world's rice, it is the major supplier for world markets. Delegates identified production and environmental hazards as their greatest concerns. Production hazards mentioned were diseases, insects, weeds, and weather effects. Environmental concerns included straw and rice-hull disposal, pesticide residues and injury to adjacent crops, and the quality of water runoff from rice fields. Solutions to many of these problems were believed to be breeding of better varieties and development of safer and more effective pesticides.

Most Important problems:

Breed new high-production, high-quality varieties that tolerate such hazards as diseases, insects, and cool temperatures. (SP)

Develop varieties that are shorter in stature, resistant to lodging, earlier maturing, resistant to blanking (floret sterility), and have good cooking quality, good flavor, and higher protein content.

<u>Corn: Production (4.3)</u> Among commodities, corn production ranked second only to soybeans as a significant research need area. Corn is first among American grain crops in acreage, tonnage, and value. Most of it (75 to 80 percent) is fed to livestock; 12 to 17 percent is exported. Although the crop has shown a fourfold yield increase in 40 years, delegates were concerned primarily with the genetic vulnerability of corn and with associated problems of breeding for disease and insect resistance.

(Corn marketing and processing were not ranked as high as production but were among the top half of all research need areas. Problems in this area include handling, drying, and storage methods to reduce grain losses and energy requirements.)

Most Important problems:

Increase the genetic diversity in order to lower its vulnerability to pests and diseases. (SP)

Increase genetic resistance to diseases and pests. (SP)

Develop improved breeding systems by such means as integrating exotic germplasm and methods of plant population improvement. (SP)

<u>Grain sorghums: Production (4.4)</u> Asia and Africa, where grain sorghum is used primarily as human food, account for half the world's production and more than three-fourths of the planted area. In the United States, grain sorghum is the second most important feed grain. The U.S. acreage is concentrated in areas with deficient rainfall, high summer temperatures, and hot winds. Drought, insects, and diseases are important production hazards. As with wheat and rice, plant breeding is considered a primary avenue for solving these problems. Improvement in photosynthetic capability was the highest rated problem.

<u>Soybeans: Production (5.1)</u> Delegates rated soybean production as the most important commodity area and second only to energy among all research need areas. Soybean oil is the leading U.S. edible oil and the meal provides 90 percent of the total U.S. high-protein oilseed meal. Production has expanded mostly through increased acreage, since yield increases have lagged behind many other crops.

(Consumer needs involving soybeans, although ranked below soybean production, are among the top half of all research need areas. Flavor, flatulence, trypsin inhibitors, and the need to improve soybean acceptance as human food were identified as consumer problems.)

Most Important problems:

Develop systems and practices to maximize yields and minimize inputs. (SP)

Develop high-yielding varieties for different production and pest conditions including root and stem rot diseases and photoperiod insensitivity. (SP)

Determine the factors that offer substantial promise in breaking yield barriers. (SP)

Expand and accelerate conventional and innovative breeding programs.

Increase knowledge of soybean genetics through cell genetics and other cell studies. (SP)

Vegetable Crops: Production (6.1) Vegetables are a major contributor to the health needs of this country. Demand for fresh and processed vegetables has grown with incomes and population. One concern of the work group on vegetables was competition by foreign producers with lower costs. In vegetables, as in a number of other crops, delegates pointed to the need for better guidelines to evaluate the significance of minute quantities of chemical residues in food products.

Most Important problems:

Develop basic new methods of improving yields such as nitrogen fixation and improved photosynthetic efficiency. (SP)

Develop varieties, machinery, and methods for mechanized production. (SP)

Develop new and improved pesticides and application methods, particularly for minor crops. (SP)

Develop and maintain germplasm banks to facilitate development of pest resistance and for study of host-parasite interactions. (SP)

Potatoes: Production (6.2) Potatoes presently supply an important caloric need for the United States, West Germany, Poland, the U.S.S.R., and other high latitude countries where the crop is adapted. Because they are one of the most efficient suppliers of calories per acre, prospects are good for using potatoes to supply more of the world food needs. Potato research needs include the development of improved varieties, better cultural practices and disease control, and improved storage methods. An increasing percentage of the U.S. potato crop is being used for processed products (frozen fries, chips, etc.). This produces waste. This waste should be used as food, feed, and byproducts.

Dry beans and peas: Production (6.3) The objective of this research need area is to provide a low-cost, high-quality protein supply, consistent with consumer needs and preferences. Dry beans, in particular, are an important protein source in

the diets of people with low incomes. Although beans are high in total protein, an imbalance of essential amino acids and the presence of antimetabolic factors lower their nutritional efficiency. Yields of dry beans and peas have improved slowly compared to cereals. Diseases of beans are a major yield-limiting problem.

Most Important problem:

Increase understanding of dry beans genetics and physiology with emphasis on crop performance. (SP)

<u>Fruits and nuts: Production (7.1)</u> The diversity of fruit and nut crops was reflected in the variety of problems identified by work groups. They ranged from tree losses and the need for more mechanized cultural and harvesting operations to better control of growth, flowering, fruiting, and fruit quality. Other types of problems included genetics and plant breeding and pest control.

<u>Harvested forages and seed production: Production (8.1)</u>
<u>Permanent, rotation, and irrigated pastures: Production (8.2)</u>
<u>Range: Production (8.3)</u>

These three need areas, all in the top 50 percent, are discussed together here.

Grasslands are the world's most widespread vegetation type. About half of the U.S. land area, approximately 1 billion acres, is used for forage, pasture, and range. The harvested forages, including seed of forage crops, are grown on tillable land. Forages constitute the basis for the U.S. sheep, beef, and dairy industries. As human food needs grow, forages are expected to provide a larger--and feed grains a smaller--share of livestock feeds.

Permanent pastures are grown mostly on land unsuitable for other crops; rotation and irrigated pastures must compete with other crops for land. Because of the greatly diverse soil and climatic conditions, research is needed to develop livestock and forage management systems suitable for specific areas.

Rangelands are in arid regions and on land not considered tillable, so improvement practices have important limitations. Delegates rated the water conservation problem highest, followed by development in semiarid regions of legumes adapted to grazing.

Most Important problems:

Collect, assess, and maintain germplasm of species for harvested forages and pasture. (SP)

Develop varieties with multiple resistance to insects, diseases, and nematodes. (SP)

Develop new approaches to minimize water loss on rangeland through water spreading, terracing, pitting, and other practices.

Animals

Beef: Production (9.1) U.S. demand for beef has increased as a result of increasing population, rising incomes, and consumer tastes. Production of grain-fed beef as a percent of total beef increased during the period of relatively cheap grain prices. Recent higher grain prices will decrease dependence on grain and increase the use of grasses and other roughages.

Most Important problems:

Improve reproduction performance of beef cattle by identifying factors that (1) increase calf survival, and (2) shorten the interval between calvings. (SP)

Reduce effects of respiratory and enteric diseases of cattle including shipping fever and calf scours. (SP)

Develop methods to increase beef production from range, silage, and pastures with new forages, fertilization, mechanical soil treatments, forage management, and livestock grazing management systems. (SP)

Pork: Production (9.2) Total pork production has not increased appreciably during the past two decades, but there have been geographical shifts and improvements in production efficiency. Pork output is centered in the main areas of feed production. A leaner type animal has reduced lard production. Reproductive efficiency has shown only marginal improvement. As producers have moved toward greater confinement of animals to increase production efficiency, problems of reproductive performance and waste management have increased.

Most Important problem:

Increase the pig crop by such means as lower mortality of unborn and newly born animals, control of estrus and ovulation, and through possibilities of very early weaning and life cycle nutrition. (SP)

Dairy: Production (10.1). Among the ruminants, the dairy cow is particularly efficient in transforming dietary nitrogen and energy into an edible product. About two-thirds of the world's milk cows are in the developing countries, but they produce only about 20 percent of the milk. The other one-third, in the United States, Canada, Japan, Oceania, Europe, and the U.S.S.R., produce 80 percent. Even with this great disparity, milk is an important source of protein, calcium, riboflavin, and other minerals and vitamins for rural people in developing countries. U.S. dairy technology can be categorized into labor-saving and output-increasing techniques.

(Although dairy consumer need problems did not fall in the top 50 percent of the total need areas, the work group gave top priority to the resolution of questions concerning nutritional value and safety of dairy products in the human diet.)

Most Important problems:

Improve methods for identifying superior dairy animals, specifically bulls and brood cows, including animals with high genetic potential at an early age. (SP)

Develop feeding systems to achieve optimum milk production in relation to costs. (SP)

Determine incidence and distribution of dairy cattle disease problems on a continuing basis, thereby detecting high priority disorders and evaluating health care systems initiated for their control.

Develop systems to increase voluntary intake of forages by cattle and improve digestibility of forages, crop residues, cereals, various processing byproducts, and nonprotein nitrogen. (SP)

Poultry: Production (10.2) Broiler production and consumption in the United States have shown sensational increases as the result of new production techniques that have made poultry much less expensive than other meats. The turkey industry generally

has followed the broiler industry in the trend toward fewer but larger farms. Egg production has not increased much, and per capita consumption is declining.

Disease control and development of feed sources not competitive with human food requirements were among the specific research needs cited.

Aquatic food sources: Production, marketing and processing, consumer needs (10.3) Problems in producing and distributing aquatic foods differ from those in nearly all other food types because about 90 percent of the world's supply is from wild sources. Almost the only human control is in rates of harvesting. Aquatic foods was the only commodity for which delegates rated all three subareas--production, marketing and processing, consumer needs--in the top half of need areas.

The more highly ranked production problems involved both open seas fisheries and aquaculture. For the fisheries, more information on the abundance and distribution of fish and shellfish in all stages of life and more efficient harvesting techniques and management systems were listed. For aquaculture, increased knowledge about the spawning, larval rearing and other requirements for aquaculture species, as well as improved methods of selective breeding, were the more important production problems identified. Marketing problems for all aquatic foods emphasized efficiency, reduction of quality deterioration and control of contamination by microorganisms. Consumer needs identified were the broad considerations of (1) developing a national policy for U.S. fisheries and (2) studying the interdependence of the needs for fishing, oil and gas, coastal zone development, and recreation.

Other *most important* problems

Only three of the 101 research problems ranked *most important* by the rating index method did not fall into the top half of the research need areas. These represent specific research needs considered extremely important by their respective work groups, even though the crops involved are not among those rated above average in need by all the delegates.

Improve lodging resistance in barley and oats. (SP)

Develop high-yielding, glandless varieties of cotton with multiple pest resistance. (SP)

Develop hybrid sunflower varieties adapted to specific production areas. (SP)

Chapter 3

PROBLEMS AND PRIORITIES WITHIN NEED AREAS

This chapter lists specific research problems considered important within each of the 49 food research need areas listed in Chapter 1 (Table 1.1).

Also included are:

- A brief statement of the overall societal objective for each research need area.

- A report on the current situation in the need area.

The importance of all problems considered at the Conference was rated. Members of the work groups developed lists of up to 40 problems pertinent to their specific research need area. They then rated each problem according to its importance for meeting the stated objective of the area.

The following scale was used:

	Value
Utmost importance	5
Major importance	4
Important	3
Minor importance	2
Very little importance	1

Based on the work group ratings, the problems were ranked and the top 20 selected for the following lists. In addition, the lists show the recommendations of other participants at the Conference and of the scientists who made their suggestions prior to the Conference. The inputs from delegates, other participants, and scientists are shown as follows:

- Delegate rankings are indicated by the numbers to the left of each statement.*

*Delegates' ratings of individual research problems often resulted in ties. All of the tied statements were assigned the higher rank order, and the appropriate following rank orders were skipped. For example, if three problems tied for second, all were assigned a "2" and the numbers "3" and "4" do not appear in that list.

• Scientists' recommendations are indicated by an "S".

• Other participants' ratings are indicated by a "P", when a problem was considered among the top 20 by delegates and scientists and also by other participants.

The ranked lists of problems in this chapter, as well as the objectives and situation statements, should be useful in developing research programs within research need areas.

All of the problems listed here, regardless of their ranking, have survived a selection process. All have considerable merit within their research need area or they would not have been included. However, in addition to those problems selected as *most important* and listed in Chapter 2, the more important problems within each research area can be quickly identified by noting those highly ranked by delegates and also considered among the top 20 in importance by the scientists and participants. After checking these, reviewers may wish to examine the remaining problems for relevance to those already selected or for merit not readily apparent.

1.1 NUTRIENT REQUIREMENTS

Objective: To ensure adequate nutrition, resulting in optimal development and productivity of people.

SITUATION

Our knowledge of the precise kinds, quantities, and balance of nutrients required to achieve optimum human health and productivity is seriously incomplete. Precise knowledge of such requirements (minimal, optimal, excessive intake) is not only incomplete for persons living in an ideal environment but it is particularly so for persons subject to dietary, climatic, or infectious stress. In meeting U.S. and world needs for food, such knowledge is as crucial as measures to increase food production.

In the past, societies have tended to rely on traditional foods, i.e., nutrients that by long common experience have appeared to meet at least the minimal local requirements. However, even under static conditions, the nutritional balance apparently achieved cannot be taken for granted.

And the corners of the earth where conditions remain static are becoming increasingly rare. Nutrient imbalances are bound to occur with the increasing use of unconventional foods (new sources of protein ... new forms of processed food ... new flows of imported foods). Much more extensive knowledge of human requirements for nutrients is needed to ensure that these unconventional foods will be wholesome and be consumed in proper balance.

Man's quantitative requirements for many nutrients are poorly defined or not defined at all. This is true for many amino acids, classes of fats, types of carbohydrates, vitamins, and trace elements. Of special importance is the determination of minimal human needs for trace elements known to be essential for numerous species of animals but for which there is no knowledge of the requirements for humans. This lack of knowledge is serious in view of the many chronic diseases suspected to be of nutritional origin.

There is a need to define exactly the minimal nutrient requirements for each age group. Equally important is clear definition of nutrient requirements for optimal health and productivity.

Intakes that prevent overt deficiency can result in suboptimal growth and development, and some damages resulting from suboptimal intakes are irreversible.

Excesses of nutrition or overnutrition are becoming ever more common in the United States, but the levels at which excesses become critical are not known.

Research has shown that malnutrition, i.e., imbalanced nutrient intake, is often much more harmful to health than undernutrition. For example, the increased intake of even a high quality protein can lead to increased mineral requirements and deficiency disease unless the protein is also a good source of the needed mineral. A marginal status of vitamin B_1 is innocuous for persons whose carbohydrate intake is marginal; but it develops into a deadly disease when carbohydrate intake is increased.

Many other examples warn of the danger to whole populations if, as expected, major changes occur in their nutritional habits.

RESEARCH NEEDS

The following were identified as the important problems that require research related to nutrient requirements.

Rank
Order

Human Requirements

Rank Order		
1	SP	Identify differences in nutrient requirements according to age, sex, occupation, and varying stress conditions, particularly for high risk groups (pregnancy, lactation, infancy, adolescence, aging).
2		Determine the best criteria for establishing nutrient requirements.
3	SP	Determine interrelationships of nutrients and other food components that affect nutrient availability.
4	SP	Determine the requirements for types and quantities of carbohydrates including fiber required to maintain health and to prevent diseases associated with imbalanced intake.
6	SP	Establish more precisely the relationship of nutrient requirements to energy needs at specific ages and physiological states.
6	SP	Determine quantitative and qualitative requirements for protein, with particular emphasis on amino acid composition.

Rank Order		
		Human Requirements (continued)
9	SP	Determine the extent of human adaptability to lowered intakes of energy and/or specific nutrients.
11	SP	Determine the human requirements for specific amounts of minerals, including trace elements such as copper, manganese, and chronium.
12		Determine the interaction between drugs and nutrients.
13		Determine criteria and methodology for assessing optimum human performance for use in developing RDA's for various nutrients.
15		Define more clearly the nutrient requirements of infants and adolescents, including optimal distribution of calories from protein, carbohydrate, and fat.
18	SP	Determine the kinds and amounts of vitamins required to maintain health and to prevent diseases attributable to vitamin deficiency.
19	SP	Determine the requirements for lipids to maintain health and to prevent diseases associated with lipid balance.
19		Identify applicable animal models that are more specifically adapted for use in long-term research relating to human requirements.
		Nutrient Deficiencies or Imbalances
5		Delineate clinical indicators of nutritional health.
8		Investigate the role of nutrition in diseases of uncertain etiology (e.g., vascular disease, cancer, congenital disease, diabetes, and obesity).
9	SP	Investigate health problems related to individual variations in the intake of foods, particular nutrients, and certain potentially harmful substances.
13		Investigate how the danger of creating deficiencies of as yet unidentified nutrients can be avoided if we rely on increasing amounts of manufactured foods.

Rank
Order

Nutrient Deficiencies or Imbalances (continued)

15 Determine relationship of nutrient status to immune response and disease resistance.

17 SP Establish the long-range effects of widespread marginal nutrient deficiencies on health, social well-being, and productivity.

S Determine the levels at which excess nutrients become a critical problem.

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1.2 NUTRIENT COMPOSITION

Objective: To provide accurate, up-to-date, and comprehensive information about the composition of important foods, the effects of processing on nutritional value, and the biological availability of nutrients.

SITUATION

Comprehensive standard reference tables on the nutrient content of foods are needed for: Estimating the nutritive value of food supplies. Evaluating the nutritional adequacy of diets. Planning special diets. Developing guidelines for selecting foods for normal diets. Planning domestic and foreign food distribution programs. Developing standards for regulatory programs. Planning and carrying out research and education in human nutrition. As well as for planning food production.

We have a reasonably good knowledge of the nutrient content of animal feeds used by the farmer. Unfortunately, less is known about the nutrient content of the foods he produces. To develop guidelines for food selection and for diets, data on the composition of foods need to be related to nutritional requirements. Guidelines for food selection should relate to the nutritional composition of the many choices of foodstuffs available to the consumer. Poor nutrition can be a problem even for the affluent (11,12).

Standard reference tables must be expanded and updated to include data on: New or modified foods. New varieties. Effects of new processing methods. Nutrients newly recognized to be of importance in human nutrition.

Equally important is the addition of some measure of variability among the values in food composition tables. It is necessary to acquire data that will permit the development of working prediction models. With a properly developed model, it would be unnecessary to make a completely new nutrient analysis when a change is imposed in one link of the total food chain. Under this system, the matrix of a food would be defined. Then the stability of nutrients would be predicted under various imposed conditions, such as: Time of harvest. Postharvest handling. Processing conditions. Storage conditions. Method of preparation in the home.

The USDA has been developing and publishing such data for more than 80 years. However, some of its major reference books have not been revised for many years.

Agriculture Handbook #8, on the "Composition of Foods: Raw, Processed, and Prepared," has not been revised since 1961 (13). For about 2,500 foods, this handbook gives values for calories, protein, fat, carbohydrate, ash, vitamin A, ascorbic acid, thiamin, riboflavin, niacin, phosphorus, calcium, iron, sodium, and potassium. For a limited number of foods, values are given for magnesium, cholesterol, and three types of fatty acids.

The USDA Home Economics Research Report on "Amino Acid Content of Food," dates back to 1957 (7). This report gives the content of 18 amino acids in 316 food items.

The Home Economics Research Report on "Pantothenic Acid, Vitamin B_6, and Vitamin B_{12} in Foods," was issued in 1969. This report gives the vitamin content of about 700 foods (6).

Various tables in shorter USDA scientific publications provide extensive data on nutrients in foods (2,8,9,10). But, except for the vitamin report, nothing new has been added to the food composition and amino acid tables in the past 10 or 15 years.

The FAO has developed tables on amino acids in foods (1). The U.S. Department of Health, Education, and Welfare has assisted in preparation of food composition tables for use in East Asia (5), Latin America (3), and Africa (4).

Despite the wealth of information that has resulted from these studies, the need continues for compilation, evaluation, and interpretation of avilable data on food composition to provide representative values for the tables. Also missing are data on the effects of food processing on nutritive values.

Data on most trace mineral elements in foods are unavailable in standard reference tables. Only fragmentary information is available for such vitamins as folacin, vitamins E and K, or biotin in foods. The same situation exists for such minerals as copper and iodine. Newly recognized nutrients causing some concern, such as chromium, call for stepped up food analyses. Data are lacking for such carbohydrates as sucrose, lactose, and starch in foods. Fiber is of increased concern to the human nutritionist, but no data are available that tell how to compute the different types of polysaccharides of fiber (holocellulose, pectin, raffinose, stachyose, etc.) in the diet. Only sparse information is available on the individual amino acids, vitamin A-active carotenoids, and fatty acid components of foods.

There is lack of knowledge about the biological availability of nutrients. Composition values for many nutrients are meaningless without accurate information about availability; this applies particularly to folic acid, iron, zinc, and probably other trace elements. Assessing protein quality and the need for developing simple, meaningful ways of predicting the complementary values of proteins continue to be problems, since measurement of biological value or net protein utilization of individual foods are meaningless when diets are composed of a variety of foods.

The best ways to present information about food composition need to be investigated, so that use will be increased and simplified. Crucial to meaningful use of the information is knowledge of the relative use of different foods as determined by surveys of food consumption.

RESEARCH NEEDS

The following were identified as the important problems that require research related to nutrient composition.

Rank Order		
		Nutrients in Foods
1	SP	Investigate factors affecting the biological availability of nutrients: (a) chemical form of nutrient, (b) interrelationship to other nutrients, (c) presence of inhibitors.
3	SP	Investigate nutrient changes in foods that occur after harvest or slaughter and during processing and distribution.
4	SP	Investigate the relationship between analytical values and biological availability.
5	SP	Develop production models for nutrient composition of foods under various systems of handling.
6	S	Analyze all nutrients and other food components that have physiological and biochemical significance in foods at all stages of production, distribution, and consumption.
9	SP	Investigate factors affecting nutrient composition of food (e.g., agronomic practices, environmental and genetic factors).
11		Identify changes in nutrient profiles resulting from genetic and agronomic research designed to increase agricultural productivity.

Rank Order

Nutrients in Foods (continued)

14 Investigate the relationship between nutrient composition and toxic substances, allergies, or other clinical manifestations.

18 Compare the effects on nutrient composition of home and commercial food preparation practices and equipment.

Providing Nutrient Information

1 SP Devise a system to channel scientific findings and analytical data from private and public laboratories into a central, computerized nutrient data bank in a form that can be readily retrieved and disseminated.

7 SP Develop data collection and retrieval methods that properly describe food materials and that provide simple means for interpreting and analyzing data in various ways.

8 SP Develop representative nutrient values for foods; regularly publish current reference tables that are as representative as possible on a national scale, but which allow for regional and seasonal differences in nutrient composition.

12 S Develop references that include nutrient composition data from other areas of the world and on unconventional sources of food.

15 S Develop information systems for securing specific values for any item.

16 Develop resource materials giving updated and completely representative nutrient values of foods.

16 Develop criteria for reporting nutritional equivalency of foods.

S Devise reporting techniques that reflect the variability of published data on nutrient composition.

Nutrient Analysis

10 SP Devise simpler methods for analyzing biologically important forms of nutrients in foods.

Rank
Order

Nutrient Analysis (continued)

13 Develop new methodology for nutrient analyses that will reduce their variability and cut the cost and amount of time involved in making such analyses.

18 SP Determine how much variance there is in nutrient content among samples, among varieties of foods, and in different areas.

18 SP Develop automated means for the analysis of nutrients in foods.

S Investigate analytic techniques and variation in results among laboratories, including methods of identifying inaccurate values in order to permit comparison of results.

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1.3 FOOD CONSUMPTION

Objective: To analyze trends and patterns in food expenditures, food consumption, and nutrient intake and their relationship to characteristics of individuals and/or households.

SITUATION

Per capita food consumption in the United States was at a record high in 1974. Average consumption of crop products reached another record high, and that of animal products was only slightly below previous highs (5). The amounts of major nutrients available for civilian consumption, per capita, generally equalled the record average of 1972.

Two important factors related to food consumption in 1973 and 1974 were a rise in retail food prices of about 15 percent and substantial increases in Food Stamp Program participation. The share of disposable personal income spent on food rose from 15.3 percent in October-December 1972 to 16.9 percent in the third quarter of 1974. These historical changes are described in two recent papers and the data are published regularly by the Economic Research Service (ERS) (1,4).

Despite the record level of average consumption in 1974, a number of critical problems related to U.S. food consumption requires that food policies and programs be reappraised and that data and analyses underlying public decisionmaking be reexamined.

Three national objectives for food consumption are interrelated:

- The U.S. population should be well fed, and every person should have access to foods that satisfy a scientifically determined minimum dietary level.

- U.S. families should have the means to obtain food for a minimum dietary level without excessive use of their resources, taking into account physical, psychological, social, and economic effects on the family.

- Current U.S. food needs should be supplied without excessive demands on public resources, allowing for some supplies to be allocated for nonfood needs of the U.S. population, for conservation of resources for future food needs, and for export to needy people.

As of early 1975, some important gaps exist in food consumption information needed to evaluate the situation with respect to these three objectives.* The available data sets are considered to be out-of-date. The latest nationwide survey data on variations in household food consumption are for 1965-66, and only a few characteristics of the families were measured (2). Therefore, analyses based on these data would not provide information suitable or relevant for current decisionmaking.

The survey of food intake of individuals, conducted concurrently with the household survey in spring 1965, was the first to be representative of the entire population. However, its usefulness is limited in that only one day's diet was considered for each individual in the survey.

Extraordinary delays in the availability of data tapes from the 1965-66 survey impeded the analyses of changes and variations, and the usefulness of the data for public and food industry decisionmaking. Even so, the indications of some deterioration in dietary levels from spring 1955 to spring 1965 spurred public and administrative interest in expansion of the Food Stamp Program (3). The household data have been used extensively as benchmarks in food market research. The individual dietary data have contributed to decisionmaking regarding enrichment and fortification, consumer protection, and nutrition labeling. The household food data are basic to the formulation of USDA food plans and to the estimation of the official poverty level. Both contribute in many ways to government policy and program determination.

Undoubtedly, changes in average food consumption, food price levels, food programs, and incomes have resulted in many changes in the consumption of individual foods by subgroups of the population, in their expenditures for food, and in their nutrient patterns. Administrative decisions on the next round of nationwide surveys have not yet been made so the earliest possible data for such surveys would be 1977.

*The need for better measurement of human requirements for specific nutrients under varying conditions and for improvements in food consumption data are discussed elsewhere. Also, the needs for research on educational and economic programs to bring about changes in consumption are dealt with in another section.

RESEARCH NEEDS

The following were identified as the important problems that require research related to food consumption.

Rank Order		
		Measures of Food Consumption
1	SP	Develop new techniques for assessing diets and for reporting the results on a U.S. and global basis.
12	S	Estimate the variation in individual consumption of foods and nutrients over long periods of time.
13		Project domestic demand for major food commodities under differing assumed conditions of price and government policy, including the effects of demand for one commodity on demand for others.
13		Identify long-range changes in consumption patterns indicated by current and perceived problems related to limited and scarce resources, e.g., fertilizer, natural gas, and phosphates.
16		Continuously monitor food consumption by a nationwide probability sample of households (individuals and families).
19		Develop ways of compiling and coordinating the food intake information acquired in many clinical situations.
	S	Analyze the current U.S. food market for all major foods.
	S	Continuously monitor food consumption by various grouping such as single households, nuclear families, extended kin groups, social-business groups, nursing homes, and day care centers.
		Reducing Wastage
2	SP	Develop principles for reducing or eliminating waste in the food and food service system.
6	SP	Provide information about the losses that occur between the production and consumption of various commodities.

Rank Order		
		Reducing Wastage (continued)
8	SP	Analyze factors related to food losses.
		Basic Research
3	SP	Intermittently survey family and individual food consumption patterns and health status with particular emphasis on disorders related to nutrition.
4		Study factors that affect food consumption patterns and food habits.
5	SP	Develop research methods to determine factors that influence the food habits of individuals and population groups so that the potential impact on nutritional status of changes in economic, social, or supply factors can be better predicted and appropriate responses (education, fortification, or other measures) can be properly designed.
7	SP	Develop and test models that interrelate (1) food patterns of households, (2) food and nutrient intake patterns of individuals within the household, and (3) socioeconomic and demographic characteristics.
9	SP	Determine the differences between nutrient composition of food as purchased and the nutrients actually consumed by individuals.
9		Compare the ultimate efficiency of providing nutrients in fabricated and highly processed "convenience" foods in terms of energy and resource inputs with that of traditional or conventional food items.
11	SP	Using representative samples, test alternative survey methods and combinations of methods.
13		Develop better definition of methods for assessing and monitoring food consumption, and then develop appropriate techniques for achieving the goals of the study.
16		Determine ways to define target groups so that frequent, small studies, which can be more accurate and more definitive, can be developed.

Rank
Order

Basic Research (continued)

20 SP Determine indicators of family socioeconomic status and social characteristics that are most relevant to food consumption.

20 Identify the regulatory factors that can influence consumption so as to benefit society economically, socially, and nutritionally.

20 Determine the factors that influence individual food choices, both as to variety and quantity.

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1.4 DELIVERY SYSTEMS: EDUCATION

Objective: To improve the diets of all people to an adequate nutritional level.

SITUATION

The World

Research contributes knowledge about the nutritional needs of people and the nutritive value of foods. Nutrition education aims to transmit this knowledge so as to improve eating practices, attitudes toward food, and habits that control health insofar as it is affected by the food eaten.

Several countries have undertaken programs of education in nutrition that aim to modify beliefs about food and to change and improve the food habits of people. Such changes in food habits tend to accompany social, economic, and cultural changes, that take place gradually over a long period of time. For example, food habits in Israel were changed through school meals provided to children (2). Results of a 10-year program designed to change food habits of mothers and infants in the Union of South Africa indicated that cultural factors are more important for some food habits than for others (1).

Education in nutrition is an essential part of programs to improve the use of national food supplies. In the East and Far East, seven countries have undertaken applied nutrition programs. But in many developing countries, information on the national food and nutrition situation, identification of the major problems, and decisions on possible solutions is not adequate to support a program in education (6). However, summaries are available of social indicators which are possible bases for identifying major problems in nutrition (8). The sophistication of a program in nutrition determines what information is required, and, therefore, affects decisions concerning support of such a program.

Knowledge of the nutrient content of local foods used in all parts of the world is prerequisite for the successful evaluation and improvement of world nutrition. Unless the composition of local foods is known, the nutritional quality of diets cannot be properly assessed, and new foods to upgrade diets cannot be introduced effectively.

The United States

Research-based guides to help people choose foods wisely have been available in the United States at least since 1916 (4). Since 1940, when the Food and Nutrition Board of the National Research Council derived the first recommended Dietary Allowances from existing research results (7), the goal of USDA food guides has been to translate these dietary standards into simple, reliable guides for the layman (11). In developing the food guides, consideration is given to food patterns, food availability, nutritive value of foods, food economics, and nutritional and dietary status. As new knowledge becomes known, the food guides are revised.

Food plans for persons of different ages and levels of activity were developed in the early 1930's (10). Through these plans, the growing knowledge about food composition and food needs was interpreted quantitatively for 12 groups of food. The plans listed weekly and yearly food supplies at different cost levels. Family food plans at four cost levels are updated to include new knowledge of food consumption, foods available on the market, and nutritional needs. Costs are also kept current. These plans are used by many agencies in planning for food allowances and monetary allotments.

Since the 1890's, USDA tables of food composition have been valuable tools for evaluating diets and food supplies and for developing guides for food selection (5). There is continuous need for updating the tables as new chemical and biological methods are standardized, food processing and preparation are changed, and new nutrients are recognized.

Basic concepts of nutrition for use in nutrition education were formulated and tested as to their feasibility in providing a framework for many nutrition programs for laymen (3). These concepts have been incorporated in college textbooks, ongoing programs, and curriculum programs.

The 1969 White House Conference on Food, Nutrition, and Health made several recommendations concerning education. One was that a curriculum in nutrition education using the conceptual approach, should be developed. Another was that qualified persons be given the responsibility for nutrition education in schools (14).

Since then, a health education curriculum with a tridimensional concept, including nutrition education, has been developed. This is one of a few sequential, K-12, curricula that has a nutrition component for use in schools (9).

Nutrition is taught by many people in many places (the home, schools, communities, institutions, advertising, and mass media). The USDA Extension Service has one of the most effective ongoing programs. But there is no ongoing sequential program for teaching nutrition; many medical schools do not cover nutrition in their curriculum; the number of qualified persons to teach nutrition is limited; and the number of institutions that prepare persons for the field of nutrition education is also limited.

The Expanded Food and Nutrition Program of USDA-State Cooperative Extension currently funded at about $50 million has great potential for direct contact with and for the education of target groups. The program contains a built-in evaluation component.

Tools recently developed for conveying nutrition information include nutrition labeling (a program of the Food and Drug Administration) and materials for school feeding programs and family food assistance programs developed by the USDA Food and Nutrition Service.

USDA research has shown that homemakers can recognize food and nutrition facts, but only a few can actually recognize nutritional balance in the daily food intake (12). Research with children to find out what factors affect the acceptability of certain foods showed that many factors were interrelated--psychological and cultural--as well as food and nonfood factors (13). In a causal model of food behavior of young couples, wives' health goals affected their food behavior and their husbands' food behavior, but wives' knowledge of nutrition had no direct effects on husbands' food behavior (15). Thus, wives' knowledge of nutrition is not a sufficient condition for sound family food practices.

A limited amount of research on food habits is being conducted at universities and by the USDA. A wide gap exists between what we know people eat and our understanding of why they eat what they do.

RESEARCH NEEDS

The following were identified as the important problems that require research related to delivery systems: education.

Rank
<u>Order</u>

<u>Nutrition Education</u>

1 SP Develop and evaluate alternative programs for nutrition education.

Rank Order		
		<u>Nutrition Education</u> (continued)
2		Develop and evaluate a media integrated campaign to combat food and nutrition misinformation to enable the public to make nutritionally sound food choices.
5		Identify effective educational techniques and strategies to modify knowledge, attitudes, and behavior regarding nutrition in both the short and long term.
5		Find ways to upgrade the basic knowledge and communication skills of the practitioners--educate the educators to be more effective in influencing people to choose wisely.
7		Develop and evaluate tools for use in nutrition education.
7		Develop techniques in nutritional assessment that will permit early evaluation of the effectiveness of special nutrition education programs.
9		Develop more effective models for coordinating and integrating nutrition education with other basic school subjects.
9		Develop and evaluate pre- and in-service education of teachers aimed at making nutrition education a valued component in teacher education.
11		Clarify the best methods for integrating nutrition into the basic sciences curricula of all medical, osteopathic, and dental schools and for using the existing faculty and/or sharing faculty among schools in close proximity.
12	SP	Evaluate nutrition education programs that make use of the interdependence of groups--mothers and children, medical schools and patients, Federal food programs and children, etc.
13		Identify the stage in human development at which the intervention of nutrition education programs is most effective.
14		Measure the degree to which nutrition education results in a change in student behavior.
15		Examine results of a comprehensive sequentialized K-12 curriculum as opposed to limited teaching of nutrition education.

Rank Order		
		Nutrition Education (continued)
16		Define a desirable knowledge base in nutrition and an acceptable level of nutritional behavior for the consumer as a basis for identifying concepts to be taught.
16		Analyze results of change in the effectiveness of nutrition education after teachers have received special training in the subject.
19	SP	Identify alternative ways of meeting nutrient needs of various family forms and cultural groups, and develop nutritional education programs for them.
19		Identify the characteristics of effective materials for nutrition education.
19		Develop and evaluate auto-tutorial minicourses in nutrition (undergraduate, graduate, and postgraduate for all health professionals).
19		Develop and evaluate a research tool to measure changes in food behavior resulting from internalized knowledge of nutrition-education.
	S	Develop a guide for the use of daily foods based on nutrient content and low cost.
		Food Intake Factors
3	SP	Identify motivational, genetic, environmental, and other factors that can change eating behavior and acceptance of particular foods.
4		Assess the effect of advertising on food consumption patterns and on the nutritional value of the diet of various segments of the public.
16	SP	Determine the effects on eating patterns of income, housing, markets, mass media, cost, and availability of food.
	S	Determine the effect on food consumption of changing employment patterns within families, including the changing roles of women.

Rank
Order

Food Intake Factors (continued)

S Determine behavioral changes that would be desirable for particularly vulnerable groups.

S Analyze the costs and benefits (social, psychological, biological, economic) of the food consumption patterns of various groups.

Food Wastage Education

S Identify the causes and extent of food waste at the household level.

S Develop ways to measure food waste at the household level.

S Develop and test education materials that aim at reducing food waste.

S Investigate the relationship of such factors as lifestyle and religious belief to the conservation ethic.

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1.5 DELIVERY SYSTEMS: NONEDUCATION AND FOOD PROGRAMS

Objective: To guarantee the availability of an adequate diet to all persons; or, if this is not feasible, to work toward a nutritional goal more realistic in relation to resources.

SITUATION

For purposes of this statement, food delivery systems are defined as public programs for the delivery of food, or of resources for obtaining food, having as one objective the provision of food needs for special population groups.

Such programs may be diverse in approach and in the population group served. Some examples are:

- Distribution of seeds and fertilizer to families to encourage the home production of food.

- Distribution of food to needy families and to institutions.

- Subsidization of group feeding of children attending day care centers and schools, the sick, the elderly, or whole communities that require emergency relief.

- Provision of supplemental income either specified for the purchase of food (as in the Food Stamp Program) or in cash (as in income maintenance programs).

The World

Equitable distribution of food to meet the needs of various segments of the population is a major problem for many developing countries. Programs designed to secure equitable distribution are being undertaken for humanitarian reasons and because of the high cost and harmful effects of malnutrition on national development.

The factors that must be considered in organizing such programs have been identified (6). However, few data are available in developing countries for making decisions about the group to be served by the delivery system, the food or other resource to be delivered, and the best procedures for delivery. Ironically, these data can be generated only by institutional frameworks such as those common in the developed countries (15).

U.S. scientists can make limited contributions to filling these research needs. The results of basic research on nutrition are transferable from developed to developing countries, but the application of the knowledge requires adaptation for each target group.

There is need for better definition of target groups, design of alternative strategies, and understanding of the cost effectiveness of potential solutions. Such planning could be an answer to the criticism leveled at scholars from developed countries that their programs are inappropriate because they are based on alien concepts, models, and theories (20).

Most FAO, WHO, and UNICEF assisted delivery systems in developing countries are oriented toward the poor, the young, and the sick. Systems tend to place emphasis on: Home food production. Supplementary feeding programs. Rehabilitation centers for the treatment of protein-calorie malnutrition (17).

Evaluation of such programs has proved difficult in many cases because of the absence of a baseline assessment and lack of commitment to evaluation. Information on the cost effectiveness of the programs is almost totally lacking. Cost can usually be estimated, but more should be known about methods of quantifying benefits.

In the first half of the 1960's, nutrition programs were widely accepted by developing countries as the answer to malnutrition. By the mid-1970's, the feeling is that many nutrition programs have failed to achieve expected results, although the number of programs that have been evaluated is small (14,17). Reasons for less than expected success include failure to make a feasibility study to ensure that the plan of operation was sound and failure to collect baseline information for evaluating progress.

Hospitalization of children with kwashiorkor and severe marasmus is a costly practice because of the long period required for rehabilitation and the treatment of numerous relapses. The less costly practice of locating and caring for mild cases at home through education of mothers, use of food supplements, and supplementary feeding programs has been tried with good results in several countries (2).

Nutrient supplements have been distributed in some countries to solve urgent nutrition problems. For example, India and Bangladesh administered heavy oral doses of Vitamin A to children to put a halt to blindness-causing xerophthalmia (1). In most developing countries where the entire population suffers from malnutrition, fortification of certain commonly used foods may be more practical.

Call and Levinson have described the differences and implications of the two approaches--supplementation for a target group and fortification for the population (5). A number of studies of the use of fortified or "new" foods as a means of raising the level of nutrition of target populations have been made in India where a research-based food and nutrition program is underway (5,13,16).

Studies of the cost-effectiveness of supplementary feeding programs were reported as "being carried out" jointly by FAO, WFP, WHO, UNICEF, and PAG in a November 1973 report of the Ad Hoc Committee on Increasing the Production and Use of Edible Proteins (10). However, no further report of these studies has been found.

Among the recommendations of the World Food Conference held in Rome, November 5-16, 1974, were:

- Assessment of the character, extent, and degree of malnutrition in all socioeconomic groups and the preconditions for improving their nutritional status.

- Review of special feeding programs to determine their desirability and feasibility.

- Exploration of the desirability and feasibility of meeting nutrient deficiencies through fortification of widely-consumed foods with amino acids, protein concentrates, vitamins, and minerals. (31)

However, the assessment, review, and exploration called for by the World Food Conference require information that is not currently available.

A Fourth World Food Survey now in preparation will provide an estimate of the number of malnourished people but will not provide a sufficient basis for an effective attack on nutritional problems (11). Such a basis requires information on the: Distribution of food, quality, and consumption, which are invariably unequal among different population groups and among individuals in the same household. Ecological base and socioeconomic conditions of those suffering from nutritional deficiencies. Caloric vs. nutrient needs. Degree and nature of deficiencies and their causes. Feasibility and effectiveness of various delivery systems for eliminating the deficiencies.

<u>The United States</u>

Despite material abundance, agricultural wealth, and a nongovernmental delivery system that makes food of good quality available for sale in essentially all parts of the country, many Americans have

diets that do not provide recommended amounts of nutrients. Studies of food consumption and nutritional status indicate that deficiencies in diets are most common among the poor, the young, the teenages, the women, and the elderly (21,22,25,26).

The 1969 White House Conference on Food, Nutrition, and Health considered the special problems of specific groups: pregnant and nursing women, children and adolescents, adults prone to degenerative diseases, the sick, the aging, and groups for which the Federal Government has statutory responsibility (30). The Conference recognized the family as the basic unit for delivery of food, affirming the need to feed the whole family and provide for special needs of certain family members. Major delivery systems existing in 1969 and initiated since are briefly discussed below.

Family Food Assistance Programs--The Food Distribution Program (FDP) and the Food Stamp Program (FSP) served about 7 million participants in 1969 (23).

The FDP, offering more than 20 different foods free to States for distribution to needy families, served about 3.5 million persons in 1969 but has been almost discontinued since.

The FSP, through the issuance of food coupons, provides eligible households with an opportunity to obtain a nutritious diet. Households receive coupons free or for only a fraction of their value. Eligibility and amount paid for the coupons depend on the income and size of the household; value of coupons received depends on household size. FSP legislation ties eligibility, coupon issuance, and the amount households pay for coupons to the estimated cost of obtaining a nutritious diet.

In 1969 about 3.5 million persons participated in the FSP; in 1974 more than 15 million. Studies indicate that more than twice this number are eligible for food stamps (4). The number of eligible households is expected to increase because of unemployment and increasing cost of food.

Frequent changes in legislation and regulations for the FSP and increasing food cost make it difficult to interpret the results of research done even a year ago on certain aspects of the program (19).

Child Nutrition Programs--The National School Lunch Program (NSLP), one of several child nutrition programs, partly subsidizes nutritious lunches served to all children, and pays all or part of the cost of such lunches served either free or at reduced prices to children from needy families.

The number of participants in this program has increased from about 28 million in 1969 to 34 million in 1974. Participants receiving free or reduced price lunches has doubled, from 4.5 million to more than 9 million. Despite these increases, only about half of the pupils in schools with the program take lunches that meet program requirements.

Other child nutrition programs subsidize school breakfasts; breakfasts, lunches, and snacks in day care centers; and lunches and snacks in summer programs at school sites, playgrounds, and recreation areas. Studies on many aspects of the child nutrition programs have been made (7,19,28).

Women, Infants, and Children Program--The Special Supplemental Food Program for Women, Infants, and Children (WIC), authorized by an amendment to the Child Nutrition Act in September 1972, provides cash grants to State Health Departments and approved local health clinics for the purpose of providing supplemental foods to pregnant and lactating women, infants, and children up to 4 years of age who are "nutritional risks" because of inadequate income (24). In 256 approved project areas, the WIC program covered 89,000 women, 114,000 infants, and 199,000 children in fiscal 1975. Studies of the effectiveness of the program in improving nutritional status and of the efficiency of delivery systems used are underway (19).

Food for the Elderly--Special nutrition problems of the aging were recognized at the White House Conference on Food, Nutrition, and Health in 1969 and at the White House Conference on Aging in 1971 (29).

Older Americans Act--Some 200,000 meals a day served to elderly persons are funded through Title 7 of the Older Americans Act. About 12 percent of these meals are delivered to homes; the remainder are served in schools, churches, and the like. An estimated two-thirds of the meals are served to the poor. Participants who can do so are expected to contribute toward the cost of meals. A nationwide evaluation of the program is underway (3).

Income Maintenance--Programs that provide cash assistance would allow the family to budget for all needs, but probably would not be quite as effective as the FSP in providing food needs since the FSP earmarks certain funds for food only. A number of research and demonstration projects conducted under the authority of the Economic Opportunity Act deal with the basic causes of poverty and dependency and methods for preventing and eliminating them. Income maintenance experiments are part of this research (27). A study of income sources and incidence of benefits from several programs indicated that food stamp and food distribution program recipients received 80 percent

of their income from public sources--usually through more than one program (12).

Fortification--Dietary deficiencies in the 1930's led to the enrichment of bread and flour with iron and three B-vitamins. The Food and Drug Administration has proposed higher enrichment levels, particularly for iron, to improve diets in the 1970's (8). Certain other foods with added nutrients--vitamin D milk, iodized salt--have been helpful in providing critical nutrients to the whole population. The Food and Nutrition Board of the National Academy of Sciences has recommended that all foods made with major cereal grains be fortified with 10 nutrients (18).

RESEARCH NEEDS

The following were identified as the important problems that require research related to delivery systems: noneducation and food programs.

Rank Order		Policies, Programs, and Standards
1		Human needs, as identified in Human Nutrition (1.1-1.5) should be given priority in guidelines for research in each of the other areas with special emphasis on public policy and international programs.
2	SP	Evaluate the effectiveness and efficiency of all existing food programs and preevaluate the potential effectiveness of new programs.
3	SP	Assess the food and nutrient needs of the United States and other countries as a basis for developing agricultural policy.
5	SP	Evaluate the impact of USDA food policies and programs and of economic and demographic changes on food consumption patterns and the nutritional status of major U.S. population groups.
6	SP	Reevaluate the use of Recommended Dietary Allowances (RDA) as a base for setting standards for food delivery systems.
9	SP	Develop a revised set of USDA food plans based on actual food patterns for use in consumer education and administration of food programs.

Rank Order		
		Policies, Programs, and Standards (continued)
16		Determine the effectiveness of alternative nutrition interventional on programs.
	S	Develop alternative standards and evaluate their effectiveness.
		Nutritional Effects
4		Develop techniques for monitoring the nutritional impact of food programs.
7	SP	Identify foods to be emphasized in the delivery system based on their contribution to health and performance.
9	SP	Study the effects of diet resulting from food programs on health, learning ability, and work performance.
11		Explore the feasibility and desirability of fortifying key foods with nutrients found to be marginally consumed in U.S. diets.
13	SP	Develop data for setting priorities for solving nutrition problems, especially the problems of vulnerable groups.
18	SP	Measure the costs and benefits of adequate diets as they relate to mental and physical health, employment and productivity, and capacity for change.
19	S	Develop models for use within educational systems and legislatures to predict the impact of nutrition on families and other social/political institutions.
		System Evaluation
8	SP	Investigate food preservation methods that have minimal dependence on energy and that can be adapted and used easily in food delivery systems.
12	SP	Find ways to link nutrition education to food delivery systems.

Rank
Order

System Evaluation (continued)

Rank Order		
13		Compare the ultimate efficiency of delivering nutrients to consumers in fabricated and highly processed "convenience" foods measured in terms of energy and resource inputs with that of providing nutrients in the form of more traditional or conventional foods.
13		Determine the impact of nonofficial nutrition educators (such as television, restaurants, and advertising) on food behavior--especially on the behavior of vulnerable groups.
17	SP	Collect baseline data and monitor the behavior of target groups in response to various food delivery systems.
20	S	Develop models to project the impact of delivery systems on the market and the economy, using Federal statistics on such factors as population, income, family composition, food supplies, and food prices.
	S	Develop methods for motivating eligible persons to participate in food delivery programs.
	S	Analyze the results and identify the spinoffs of delivery systems and food programs.

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2.1 FOOD TECHNOLOGY

Objective: To make available (assemble, improve, develop, process, preserve, protect, and store) safe, wholesome, nutritious, and high-quality foods at reasonable cost.

SITUATION

The World

In view of the present and projected world food situation, it is important that the developed nations share their food production and their food technology with nations that face grave shortages in the supply of essential nutrients.

Today, it is estimated that half of the world population is affected by some degree of hunger or malnutrition. The deficiency involves both caloric and protein needs.(1).

Based on FAO criteria, one-third of the world's peoples, living in developed countries, have about 120 percent of their caloric requirements. The remaining two-thirds have a caloric deficit of between 7 and 14 percent. Although the total world supply of protein appears to be ample, major inequalities and dislocations affect large numbers of people (2).

Projections indicate that by 1985 the developing nations will have 80 percent of the world population but will be producing only 50 percent of the world's food. This indicates that developing nations as a group will be more dependent than ever on food imports.

Science and technology have been applied to the problems of preserving and processing foods so that they may be transported, stored, and presented to consumers in a safe, palatable, and nutritious form--both within and between nations.

Most foods are perishable. They begin to deteriorate soon after harvest, gathering, or slaughter. Because much food is produced at great distances from population centers, it must be processed to provide time, form, and place utility. Thus, between the farm and the consumer's table, food goes through many steps--sorting and grading, processing, packaging, storage, distribution, and marketing.

Enormous losses occur during the storage, transport, and distribution of food. Much of this loss is due to pests, the nature of the food, lack of protection, and condition of storage. Some estimates suggest that half the foods produced never reach the consumer (3).

Continuing advances in food science and technology have heralded a changeover from fresh, perishable foods to stable, storable processed foods. Food processing and preservation help to make the food supply more stable for both developed and developing countries.

To be successful a new food processing method should meet one or more of the following criteria:

- Perform an old job at lower cost.
- Produce food of better quality, including better retention of nutrients.
- Provide a new product acceptable to consumers.
- Yield a food for a special application.
- Use as a raw material some product not now used.
- Result in a higher yield of edible components or more valuable byproducts.
- Reduce adverse environmental impacts.

Preservation helps to:

- Provide time, form, and place utility that permits use of foods at places far removed from their place of origin.
- Avoid waste.
- Prevent losses from spoilage and deterioration.
- Minimize seasonal fluctuations in food availability.
- Avoid great fluctuations in food supply and prices.
- Even out the supply of nutrients during interharvest periods.
- Correct nutrient deficiencies through supplementation or fortification.
- Assure proper use of foods.

Some relatively old techniques, such as dehydration, canning, cold storage, and freezing have proven their value, particularly in the developed world. The newer preservation methods, such as freeze-drying, aseptic canning, irradiation, extrusion processing, and membrane processing (reverse osmosis and ultrafiltration) are finding greater application and providing processed foods of even higher quality.

Despite these scientific and technological successes, further advances are needed to cope successfully with world and local food requirements even in the near future. Greater use of byproducts and other underutilized materials is a necessity. Generation of processing wastes (pollution) and energy consumption must be reduced. New low-cost forms of acceptable protein foods must be developed. Entirely new sources of foods and new combinations or mixes of food ingredients must be found. New systems of food distribution and food service will be required. Affluence among Americans and in othr developed countries is causing shifts in consumption patterns. Raw food materials, especially those from grain and oilseed sources and possibly leaf proteins, require more efficient conversion to human food. Even greater challenges will be met in protecting, packaging, and delivering the food from places of production to places where it is consumed. Improved means for alteration, enrichment, and fortification of foods and more effective processing, storage, and distribution systems must be developed.

The United States

Skillful use of technology by the U.S. food industry has enabled the United States to preserve and distribute its food products in a very éfficient manner. At a cost of about 17 percent of their income after taxes (February 1975 National Food Situation), Americans are the best and most economically fed people on earth. The ability of the United States to consistently produce food surpluses has made it possible to divert more than half of its food production to help feed a hungry world.

U.S. agricultural exports for the year ended June 30, 1974, were valued at $21.3 billion, a gain of 65 percent over the record high set in 1973. If the United States is to maintain this level of exports, it must develop new technology to offset the complications of the energy crisis and the rising costs of inflation.

Advances in science and technology are also required to keep pace with the rapidly changing demands of the U.S. domestic market. U.S. food consumption patterns are changing, and taste patterns must be recognized. Americans are seeing a greater variety of foods on the grocery shelves, including new foods and foods improved through

better processing methods. U.S. consumers continue to express their strong preference for convenience foods. As a result, more processed foods are being consumed, and the demand for snack foods and fast food service is growing very rapidly. The eating out trend (projected at 50 percent of all meals by 1985) will have a profound influence on the food industry, consumers, and social systems. Thus, the food service industry and its technology warrants a comprehensive reappraisal.

In 1973, U.S. citizens spent $139 billion for food--an average of $600 for every man, woman, and child. Of each dollar spent for food, 56 cents went for animal products--meat, milk, and eggs.

Americans have access to the highest quality, best balanced, most economical food supply in the world. But for some individuals and population groups, food consumption patterns are far less than ideal. Significant improvements are likely to result from further research and education addressed to the needs of this segment of the population.

The present U.S. research effort on food science and technology is being conducted by university scientists in the 50 states, in the USDA, and other government-based laboratories, and in private laboratories supported by the food industry.

RESEARCH NEEDS

The following were identified as the important problems that require research related to food technology.

Rank Order		
		Storage and Handling
1	SP	Develop low-energy systems and equipment for preparing food items in food processing plants, the food service operation, storage, and distribution. Include evaluation of the effects of the processing change and the microbiology of the food to ensure it is safe and suitable for the public.
2		Search for new techniques to reduce the cost of sanitation methods for food processing operations to reduce chemical, energy, and water expenditures.
2	SP	Develop methods and equipment to collect, treat, and dispose of food wastes or to use them for food, feed, or byproducts.

Rank Order		
		Storage and Handling (continued)
4		Develop recovery processes in food systems to yield new products from process wastes.
6	SP	Develop new technology to reduce costs and to deliver high-quality products to consumers.
7	S	Develop a model for evaluating waste generation from food source to consumer.
7		Devise ways to reduce water requirements in food processing.
10	S	Measure fuel and human energy expended in food preparation, including energy necessary for food storage.
18		Develop equipment and procedures to minimize heat loss during food production in food service operations.
	S	Monitor effects of food handling practices, in homes and institutions, on (1) microbiological, toxic, and other hazardous substances in foods and (2) nutritional value of foods.
	S	In group feeding programs (satellite feeding programs, meals-on-wheels, etc.) determine the effect of time, temperature, and amount of food on microbiological safety, quality, and nutrient retention.
	S	Devise ways to remove foreign matter and toxic or harmful substances from processing water so that it can be recycled.
	S	Develop methods to monitor handling of food during commercial processing, storage, transportation, and marketing.
	S	Reevaluate home preservation methods in light of microbiological safety and of effects on palatability and nutrient retention.
	S	Develop a packaging system that will indicate mishandling regarding temperature during storage.
		Improved Products and Processes
5	SP	Determine the social and economic feasibility and nutritive possibilities of new or improved foods and processes.

Rank Order		
		<u>Improved Products and Processes</u> (continued)
11	SP	Develop and improve packaging materials to prevent deterioration and damage during storage and transport.
11		Develop packaging materials that are biodegradable and may be used in agricultural production as solid texturizers or fertilizers.
17		Develop ways of preserving grains by chemical means independently of or in combination with microwave or other forms of irradiation.
		<u>Food Quality</u>
13		Reduce losses of food supplies by molds and other microflora, specifically cereal grains during storage and processed foods.
14	SP	Evaluate storage conditions for perishable, nonperishable, and convenience-type foods in terms of safety, palatability, and nutrient retention.
15	SP	Increase the knowledge of loss of nutritive value by processing during all stages.
19	SP	Develop criteria for food quality standards in terms of nutrition, wholesomeness, and acceptability.
	S	Develop instrumentation to measure quality factors simply and rapidly.
	S	Determine how physical environmental factors (temperature, moisture, gasses, etc.) affect food quality.
	S	Determine environmental effects on food composition, nutritive value, and safety.
		<u>Special Needs</u>
9		Establish a national educational campaign for intensive energy conservation techniques within the food service industry.
16		Determine the effect of regional food processing operations upon food distribution costs.

Rank
Order

Special Needs (continued)

19 SP Obtain knowledge about food practices and habits of consumers.

19 S Establish guidelines for food preparation and service in homes, institutions, and food service establishments.

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2.2 NONCONVENTIONAL FOOD SOURCES

Objective: To develop nonconventional foods that will add to the human food supply and meet requirements for nutritional value, safety, consumer preference, and cost.

SITUATION

The growing concern over food shortages and scientific curiosity have stimulated interest in the development of nonconventional food sources. These are being developed in the anticipation that calories, proteins, and other nutrients from all possible sources will be required to meet the global needs for food.

Only a relatively few plants and animals are now being used as food sources. These were selected and domesticated by our prehistoric ancestors largely on the basis of their palatability. Even though science has improved food production, preservation, and distribution, most protein foods are still those original ones. In marked contrast, other human needs such as those for clothing, housing, transportation, communication, and medicine are being met with materials and methods vastly different from those our ancestors used. Certainly science and technology can provide new and different food supplies. Promising sources include soybeans, whey proteins, cottonseed, peanuts, rapeseed, coconuts, wheat, fish, agricultural and food processing wastes, leaves, and single cells.

Of the nonconventional food technologies, the one utilizing soybeans is most advanced. Soybean proteins in a variety of foods are becoming available on the market (10). In addition, proteins from peanuts, coconuts, wheat, and fish have been used as extenders or substitutes for milk and cheese (5,9). Whey proteins have been used as inexpensive alternates to other foods as well as key components in a variety of nonconventional foods. Cottonseed and peanuts could be not only competitive with their soybean counterparts but also may find new sources of their own (4).

Processing technology is being developed to obtain food byproducts from celery trimmings and other leafy crop residues. The products include oils with odors of the fresh material, protein concentrate, cellulosic fillers, and concentrated juices (2). Developing the potential high yields of protein or oil from seeds and pulp of squash and cantaloupes has been proposed.

Fish protein concentrate from the complete utilization of seafood is being produced commercially in the United States and in other countries (8).

Leaves and juices of green plants are the primary and most abundant sources of proteins. Leaf proteins can be obtained from many plant juices by precipitation with heat, organic solvent, and acid extraction methods. The most promising leaf-producing plants are the legumes, particularly alfalfa (7).

Single-cell proteins (SCP) have been obtained from cells growing on paraffins, methanol, ethanol, sugarcane, and a variety of agricultural, municipal, and industrial wastes. The cells grown on these substrates are selected species of algae, bacteria, and yeast. Some problems have been encountered with carcinogenic contamination of the product when produced by petroleum fermentation. Based on current technological progress, single cell proteins are not expected to be widely available as a protein source for human food before 1980 (1,6).

One important potential market for these products is their direct use as human food. However, some of them, particularly single-cell and leaf proteins, are being evaluated first for livestock feed either as interim uses during technological and commercial development or as ultimate uses.

All of these food sources must satisfy similar criteria that must be met if they are to be generally used. These involve their nutritional value, sensory quality, safety, functional characteristics for food product formulations, adaptability to consumer preferences, legal approval, and cost. If these new foods are not fabricated into appealing products, they will not be eaten (3).

In addition to their potential for increasing the total food supply, nonconventional sources also may increase the opportunities to provide nutritionally desirable mixtures adapted to differing habits. It is vital to the usefulness of these sources, however, that they have either an agricultural production base or some equivalent source of production that will assure a commercially adequate supply of consistent quality.

RESEARCH NEEDS

The following were identified as the important problems that require research related to nonconventional food sources.

Rank
<u>Order</u>

<u>Processing Wastes</u>

1 SP Develop animal processing byproducts as protein resources, particularly edible grade blood.

Rank
Order

Processing Wastes (continued)

Rank Order		
2		Develop techniques for processing large quantities of "inedible" and "condemned" animal carcasses and parts into wholesome, culturally acceptable forms of human food.
6		Expand efforts to utilize blood as a human protein source.
15	SP	Develop ways to use leafy processing wastes as protein and fiber sources.

Basic Research Needs

Rank Order		
3	SP	Improve ways to analyze quantity and quality of food proteins.
4	SP	Determine the chemical, physical, and structural qualities of various proteins that affect their function in food systems.
5		Develop strategies for introducing nontraditional foods into the food habits and customs of the consumer, regardless of social and cultural patterns in terms of acceptance or rejection of food.
9		Develop fermentation processes to convert present nonfood materials such as cellulose containing agricultural products into edible substances.
9		Develop flavors and colors to be added to new engineered foods.
20		Develop analytical tools for measuring flavors.
	S	Develop ways to evaluate potential food protein sources in light of consumer needs in particular regions, processing requirements, and economics.

Single-Cell Proteins

Rank Order		
7	SP	Develop methods to use the vast amounts of yeast-grain protein produced by distilleries and breweries.
18	SP	Evaluate methods for using single-cell proteins in foods without removing all cell walls.

Rank Order		
		Single-Cell Proteins (continued)
	S	Develop methods of using enzymes to treat yeast cell walls.
		Soy and Cereal Protein
7	SP	Determine the least-cost method of producing soy products with good flavor and functional properties for a particular use.
12	SP	Determine the potential for blending soy proteins with other plant proteins.
14		Process triticale for food products and evaluate their properties.
17		Develop oat and wheat protein products from high-protein varieties and evaluate them in food systems.
a/	S	Eliminate the off-flavor of soy-based products.
	S	Develop corn germ protein isolate with required qualities--texture, flavor interaction with other foods, fiber composition, etc.
	S	Evaluate and improve grain sorghum as a protein source.
		Seafood Byproducts
9	SP	Improve processes for separating usable proteins from fish and fishmeal processing wastes.
13	S	Compare potential seafood byproducts with alternative food sources, including such factors as availability of raw materials, feasibility of central processing, and economic potential.
		Plant Juices or Leaf Protein
15	S	Search for sources of leaf proteins in plants native to Asia, South America, and India.
19	SP	Compare the economics of leaf protein extraction and disposal of the residue with the use of leaves as cattle feed.

Rank
Order

Plant Juices and Leaf Protein (continued)

S Develop an economical method to prevent off-color when leaf protein is incorporated into foods (action of chlorogenic acid).

S Develop ways to use the liquid "whey" produced during preparation of leaf protein.

S Develop machines and systems to harvest fresh plants, extract the juices, and preserve high-quality protein.

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a/ Included by delegates in research need area 5.1 Soybeans with an importance rank of 9.

2.3 FOOD SAFETY

Objective: To provide safe, wholesome, and nutritious food that can be consumed by people in all countries.

SITUATION

Human foods and human beings are extremely complex biological and chemical entities. The reactions between an individual and his foods are even more complex. Under one set of conditions certain food components are harmless; under other conditions they may become toxicants.

Food toxicants can be normal components of natural foodstuffs, in which case they are called natural toxicants; or they can be added either intentionally or unintentionally, in which case they are called manmade.

Natural toxicants include substances that are normal components of food products (for example, natural contaminants such as microbiological toxins and other toxicants such as metals).

Manmade toxicants include such materials as agricultural chemicals, food additives, and chemicals added inadvertantly or accidentally.

Much progress has been made in identifying the natural toxicants in a wide variety of food crops, but there are still wide gaps in our knowledge of the safety of those that have been identified as well as of those still unknown. Nothing is wholly safe or dangerous *per se*; it is the quantity involved, the manner and conditions of use, and the susceptibility of the organism that determine the degree of safety and hazard (5).

A normal, healthy person who consumes a varied diet containing many potentially or actually toxic chemicals usually experiences no adverse effects. However, under some circumstances, these toxicants can be extremely harmful to some individuals (1). To help control this problem, the Food and Drug Administration promulgated regulations to prevent significant alterations in nutritive value and toxic constituents through plant breeding and selection (8).

Of immediate concern are the toxins in the Cruciferae, Leguminosae, and Solanaceae and the metabolites of a wide variety of molds (2,3).

There has been worldwide concern over the use of chemicals or antimicrobials, antioxidants, emulsifiers, stabilizers, or other additives intended to restore, enhance, or introduce a particular

Rank Order		
		Contaminants (continued)
12		Determine whether the handling or consumption of swine bearing *Mycobacterium avium* organisms is an actual human health hazard.
15		Determine the causes of mycotoxin contamination of foods.
20	S	Determine the harm potential of contaminants.
	S	Develop methods to control desirable and undesirable changes in foods resulting from enzymes, protein reactions, chemical interactions, etc.
	S	Investigate ways to educate consumers to accept alternate foods if necessary and possible.
	S	Discover potential problem materials.
		Chemical Residues
7		Develop methods and principles for understanding pesticide behavior which may serve as data bases for the scientific community.
8	SP	Evaluate the levels of chemical residues acceptable from the public health viewpoint.
10		Study the effects of integrated pest control management programs and practices on the movement and bioaccumulation of pesticides in the environment.
14	SP	Develop food processing methods that minimize the levels of harmful residues in foods.
17	SP	Study factors affecting the levels of residues in foods.
18		Evaluate the effect of food processing on chemical residues and develop food processing methods that minimize the level of harmful residues in foods.
	S	Develop more knowledge of the usefulness and safety of food additives.

characteristic into food (4,6,7). It is unrealistic to believe that our own needs, much less those of the world, could be met without the use of food additives. They have prolonged the shelflife of foods, have reduced cost from spoilage, and made a wide variety of safe and nutritious food available to many people throughout the world.

In America, pest control is essential if we are to maintain our standard of living, but in other parts of the world pest control is a matter of survival. Pesticide chemicals can be the most effective and least expensive way of controlling pests, but there is a continuing concern over the safety of chemical residues. The development of new plant varieties resistant to insects and disease holds promise but the timelag is too great to provide immediate solutions. However, economic, political, and social pressures may force us to accelerate our efforts in this direction.

In summary, the real challenge is to discover how to determine whether and under what conditions of use such additives constitute a health hazard in either the long or short run.

RESEARCH NEEDS

The following were identified as the important problems that require research related to food safety.

Rank Order		
		Contaminants
1	SP	Determine methods of handling contaminants--removal, detoxification, dilution, etc.
2	S	Determine ways to avoid contamination, including new equipment, methods, and varieties.
3	SP	Develop quick methods to detect contaminants in foods.
5		Study the effectiveness and safety of chemical and physical methods of detoxifying mycotoxin-contaminated foods.
6		Develop new sanitation techniques which require less water, energy, and chemicals but retain the same efficiency as conventional methods.
11		Develop harvesting systems that will bring the commodity from the field to storage without increasing its aflatoxin content.

Rank Order		
		Natural Toxicants
4		Establish means for controlling the formation of toxic phytoalexins in food plants.
8		Develop specific antibodies for use in rapid serological tests for natural toxicants, contaminants, and chemical residues that are major control problems.
13		Determine levels and modes of formation of toxic phytoalexins in food plants.
15		Determine which food plants produce abnormal, toxic metabolites (phytoalexins) when subject to physiological stress.
19		Determine hazard potential of new plant varieties.
	S	Discover potential problem materials.
	S	Investigate ways to educate consumers to accept alternate foods if necessary and possible.
	S	Determine methods of handling natural toxicants when present--removal, detoxification, dilution, etc.
	S	Investigate the harm potential of natural toxicants.
	S	Determine methods to avoid natural toxicants.

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3.1 LAND

Objective: To efficiently use land resources and to optimize the productivity of agricultural land consistent with human needs and the requirements of conservation, environmental quality, and long-term use.

SITUATION

The World

According to FAO data, a world total of 1.4 billion hectares (3.4 billion acres) of land is being cultivated to grow food crops or feed livestock (2). The distribution of this land by countries and regions is shown in Table 1.

A recent study by Iowa State University estimates that 3.2 billion hectares (7.8 billion acres) could be used (1). Thus, the opportunity exists to more than double the acreage of land used for food crops and livestock. There is concern, however, that the potential productivity of the land added would be less than that now in use. Increased use of currently available technology also is necessary before much of the additional land could be used efficiently. Increases in the use of land for producing grains have been occurring at a rate of 1.1 percent per year in developing regions. There has been very little increase in grain acreage in developed countries, and the rate is only 0.3 percent per year in the world as a whole (3).

Even though the world is not short of potentially arable land, there are serious regional shortages, particularly for some of the developing countries (3). A large proportion of the world's people live in areas such as India, Bangladesh, and Egypt where possibilities for acreage expansion of cultivated crops are very limited. Also, industrial nations such as Japan and certain western European countries have little potential for increasing the amount of land in crop production. Moreover, in many of the heavily populated areas where land is in short supply, the soils are low in productivity. Soil degradation and use of land for nonagricultural purposes are also important limiting factors in world food production.

The world food problem requires greater production of crops of improved quality from land now being used for agriculture, including rangelands, plus opening of new lands for agricultural use. These steps must be achieved with a relatively high level of efficiency in use of capital, energy, and fertilizers and with methods that will minimize the possibility of damage to land and water resources.

The United States

Land for crops, grassland pasture, and range comprises by far the largest land use in the United States (4). The other uses are for forestry, urban areas, roads, reserves, and parks.

Even though the land for urban uses has about doubled and the population has grown by one-third since 1950, the total land available for food production in the United States appears to be adequate at least until the year 2000 (3,4). However, only new developments in technology and their application will make it possible to maintain the present relatively low cost of food production.

Local problems exist where urban development, transportation corridors, and other uses undermine the economic viability of agriculture. These problems, however, may be of less significance nationally than those of conserving and improving the productivity of the soil.

The present research effort on soil and land use amounts to 440 scientific-man-years. It is conducted at universities in all States and at 81 locations of the USDA.

Research and technology have made major contributions to the maintenance and improvement of land productivity. Soil surveys and classification have been completed for nearly half the area of the United States. The classification recognizes more than 80,000 specific kinds of soils.

The major characteristics of the different soils are being determined, and a program of computer storage and retrieval of this information is being developed. Reasonably adequate methods of estimating requirements of specific soils and crops for lime, phosphorus, and potassium have been developed. Estimates of requirements for nitrogen and secondary elements need additional testing against field responses. Optimum combinations of inputs of tillage, fertilizers, and herbicides have been worked out for a few crop-soil combinations, but are not yet established for many others, especially on soils of unfavorable slope or physical properties. Tillage methods that reduce energy requirements, conserve water, and reduce erosion have been developed for some situations, but erosion continues to be a serious problem on deep soils formed from silty or clayey materials. There is limited knowledge of the response of different range lands to rehabilitation, fertilization, and controlled stocking.

RESEARCH NEEDS

The following were identified as the important problems that require research related to land.

Rank Order		
		Land Management and Fertility
2	SP	Develop reduced-tillage practices economically feasible for use with a wide range of soil, climate, and crop conditions.
4	SP	Develop tillage and planting systems emphasizing conservation and control of soil erosion.
9		Conduct basic research relative to machine-plant-soil-residue interface and to soil preparation, seed placement, and chemical placement for all crops.
13	SP	Determine the best stocking rates for different kinds of animals, including wild animals, on different types of rangeland.
13		Assess the impact on land management of greatly increased coal and shale oil mining.
19	SP	Incorporate into nonlegume food and forage crops the ability to symbiotically fix nitrogen.
19		Determine on-site versus off-site costs and benefits of applying soil conservation practices.
	S	Develop ways to better control rates at which plant nutrients become available or unavailable in the soil.
	S	Determine the best methods to manage vegetation and to manage or control pests and predators for improved forage and livestock production.
	S	Develop better ways to improve infiltration and storage of water in soils.
		Erosion and Pollution
2	SP	Evaluate the impact of wind and water erosion on long-term soil productivity and crop yields, in relation to environmental quality.

Rank Order		
		Erosion and Pollution (continued)
9		Determine environmental consequences of increased application of animal wastes to cropland. Develop and demonstrate waste and land management practices that avoid the degradation of farmlands from agricultural chemicals, irrigation return flows, and animal wastes.
13		Determine the effects of slope length and slope steepness on soil erosion for long, steep, and flat slopes for which data has not been obtained. Improve and further refine procedures for assessing water erosion damage to soils, crops, and environment over a wide variety of climate and geomorphic conditions.
19		Develop and improve procedures based on statistical sampling techniques and a weather-land model for determining annual wind erosion damage to soils, crops, and environment and for predicting potential wind erosion prior to critical wind erosion seasons.
	S	Determine costs and benefits of different systems of applying farm manures to land, in order to minimize pollution and reduce need for purchased fertilizers.
	S	Determine the suitability of using waste effluents to provide nutrients and water for crop production.
	S	Determine adverse effects of heavy metals and other constituents in sewage sludge when it is applied to soils; develop methods to minimize crop uptake.
		Resources Appraisal and Allocation
1		Develop plans for retaining lands as agricultural or open space with emphasis on proper compensation for present owners.
4	SP	Develop methods to use land inventory information in designing land management policies which take land characteristics into account.
4	S	Develop a detailed classification system based on land use potential, to serve as a basis for land resources management policies.

Rank Order		
		Resources Appraisal and Allocation (continued)
4		Analyze the interface between agricultural land use, the contribution of marsh productivity to aquatic food chain and the related production of food for man in the aquatic ecosystem.
4		Determine the land use implications, along with the economic, social, and environmental consequences, of a vastly expanded agricultural industry.
9		Assess Federal, State, and local programs to preserve prime agricultural lands and analyze the economics of conservation, intertemporal resource use, economics of conservation subsidies, land banks, and other programs to preserve or conserve land.
12	SP	Determine the feasibility and the trade-offs involved in using productive agricultural land for multiple or alternate uses.
16		Develop plans for municipal units of government buying development rights in order to maintain agricultural land.
17	SP	Determine required inputs (irrigation, fertilization, drainage, clearing, etc.) to convert potentially arable lands to various agricultural uses.
17	SP	Develop models of potentially arable lands that can be used to evaluate proposed development programs in terms of expected production, required inputs, and economic and social policies.
19		Determine potential environmental impact of increased utilization of marginal quality lands for crop production.
19		Determine the economic and environmental costs (e.g., soil losses to erosion) of bringing increasing amounts of land, classified by region, into production in response to high and rising export demand for grains and soybeans.
	S	Inventory potential new arable land areas, including their soil, climate, and physical conditions; determine their potential for various food crops.

Rank
Order

Resources Appraisal and Allocation (continued)

S Identify characteristics of soils and associated resources in farmland areas that will help establish land use priorities and soil conservation practices.

S Determine the relationship between soil productivity and pre-unit cost of production for major crops in various regions.

S Develop computer systems to store, interpret, and retrieve data on soil and climate in different areas.

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Table 1. Cultivated and Irrigated Land by Country or Region--1970.

Country or region	Cultivated land	Irrigated land	Irrigated	Persons per irrigated hectare
	million hectares		percent	number
World	1457.00	203.61	14.0	17.8
Europe	145.00	12.29	8.5	37.6
EEC-9	52.38	5.35	10.2	46.6
Eastern Europe	46.02	2.67	5.8	38.9
USSR	232.61	11.10	4.8	21.9
North America	236.09	16.18	6.9	14.0
United States	192.32	15.38	8.2	13.3
Canada	43.77	.35	0.8	60.0
Oceania	47.00	1.60	3.4	11.9
Australia and New Zealand	45.44	1.60	3.5	9.4
Asia	463.00	145.71	31.5	14.1
Japan	5.45	2.63	48.2	39.2
China	111.20	76.00	68.3	10.0
India	164.61	27.52	16.7	19.5
Indonesia	18.00	6.80	37.8	17.1
Latin America	118.92	10.41	8.8	27.2
Mexico	23.82	4.20	17.6	12.1
Brazil	29.76	.46	1.6	202.2
Africa	214.00	6.34	33.0	54.3

Source: A Hungry World: The Challenge to Agriculture. General Report of the University of California Food Task Force, July 1974.

3.2 WATER

Objective: To develop, conserve, and efficiently utilize present and potential water supplies for food production with due consideration for other uses and for environmental quality.

SITUATION

The World

Most of the world's cropland is watered by natural rainfall, and rainfed agriculture produces most of the staple food. However, to successfully meet world requirement for food, it will be necessary to improve irrigation, drainage, flood protection, and precipitation management.

Some of the world's most fertile soils are in areas where natural precipitation is insufficient for agriculture. Irrigation is crucial in these areas.

More than 200 million acres of the land surface of the earth are under irrigation (Table 2). China, India, the United States, Pakistan, and the U.S.S.R. account for more than 70 percent of the world total (3). Taiwan, Egypt, China, Japan, and Pakistan are leaders in percentage of cultivated land irrigated. Rice is the major irrigated crop in many countries, and such crops have relatively high yields. In Japan, Taiwan, and South Korea, the leading Asian nations in terms of rice yields, more than half the rice acreage is irrigated.

Irrigation has been a major factor in the "Green Revolution," and it is vitally needed if farmers in the developing nations are to continue to increase their production. Although the new high-yielding varieties of rice and wheat have a proven potential, their use does not automatically guarantee higher yields. To realize the high potential of the new varieties requires heavier application of inputs and especially improved and more precise management, including the timing and amount of water application. Improvement of irrigation management to enable farmers to increase efficiency of water use and more fully utilize the potential of new technologies is becoming increasingly important (1).

Drainage of agricultural lands is important in both irrigated and naturally watered areas. Poor drainage limits plant growth and crop yields in many areas that have fertile soils and also can

contribute to salinity problems on irrigated lands. Water erosion control is needed to maintain the natural productivity of soils and to prevent losses of fertilizer and the accumulation of sediment and infertile overwash on cropland. Protection from flooding is needed to increase productivity in most of the world's major river basins as well as in tributary valleys.

Precipitation management is an emerging discipline that may have potential for increasing food and fiber production. Cloud seeding to increase snowfall and snowpack in mountainous areas is being studied. If successful, these efforts could add to supplies of irrigation water as well as rainfall during the growing season. Hail suppression is another example of precipitation management that could reduce crop losses.

The United States

Water is vital to agriculture, and agriculture strongly influences the water supply. More than 70 percent of the precipitation for the 48 contiguous States evaporates or is transpired from vegetation (2). Roughly one-fourth of this evapotranspiration is from agricultural land. The remaining 30 percent of the precipitation is natural runoff and can be considered the effective renewable supply. But substantial accumulated ground water, a stock resource, augments this supply. Ground water reserves, not all of which can be economically tapped, are equal to about 30 years of runoff. In the 17 Western States, about 78 percent of total water withdrawals is for irrigation. Water withdrawn for irrigation represented almost 36 percent of all withdrawals in the United States in 1970 (4).

Only about one acre in every ten of farmland was irrigated in 1969, but irrigated agriculture produced one-fourth of the value of farm crops. Although total withdrawals for irrigation will continue to fall relative to withdrawals for industrial, municipal, or steam-electric power purposes, irrigation is expected to remain the principal consumptive use of water. Greater efficiency in water use in irrigated and rainfed agriculture is mandatory if there is to be sufficient water for optimum crop growth and successful conservation of our limited water resources. Water conservation measures, including improvements in scheduling irrigation, control of phreatophytes, and recharge of ground water supplies, can contribute to efficient water use.

More than 100 million acres of agricultural land can benefit from improved drainage. Additional land can be brought into the cropland base through drainage of wetlands, although this may result in losses of forest products and environmental assets. Control of water erosion is a major problem on about 179 million acres of cropland. The need for flood protection is emphasized by an

estimate that flood damages in upstream watersheds average more than $1 billion annually (4).

Many of the measures recommended for improved management of water resource can be implemented by individual farmers. Others require cooperative action by groups of farmers, frequently with public participation in the form of financial and technical assistance. Management and development of water resources will continue to be an important issue in public policy. Close cooperation by all levels of government and private efforts will be needed to produce an institutional setting in which water can be used effectively in the production of food and fiber.

Research and technology have made major contributions to increased water supply and efficiency of water use, reduced labor requirements, and reduced potential for water pollution from agricultural sources. Water supplies can be stretched or increased by suppression of evaporation from water surfaces, reduced seepage and runoff, control of water wasting vegetation, and, in some areas, use of treated sewage effluent for irrigation and recharge of ground water. Selection or breeding of better adapted crop varieties and improved cultural practices also reduces water requirements. Drainage of agricultural lands is being made less costly by the development of improved installation techniques and use of new materials. Initial information is available for the design of systems to reduce and control point source and nonpoint source discharges of agricultural effluents.

The present research effort on water for agriculture amounts to 575 scientific man-years. It is conducted at universities in nearly all States and at 112 USDA locations.

RESEARCH NEEDS

The following were identified as the important problems that require research related to water.

Rank
Order

Legal and Institutional Considerations

1 SP Determine the most efficient combination of water and related land laws, water rights, and market mechanisms to develop, conserve, and efficiently utilize water supplies, including ground water.

2 SP Determine impacts of Federal and State water quality legislation and administration on water development and food production.

Rank Order		
		Legal and Institutional Considerations (continued)
	S	Evaluate market and nonmarket mechanisms for increasing the efficiency of water use.
	S	Examine the potential benefits and constraints of consolidating flood control, drainage, and irrigation districts.
		Quality of Water
2	SP	Improve soil and water management to control erosion and sedimentation.
5		Develop an improved system of environmental monitoring to detect problems, such as those that have developed from PCB's, hexachlorobenzene, and other substances that have produced unexpected ill effects.
6		In the 17 Western States and in selected parts of the developing world, determine the costs, in terms of reduced yields or of measures necessary to maintain yields, of increased water salinity resulting from irrigation return flows.
9	SP	Develop methods for recycling irrigation water and maintaining the quality of surface streams and ground water.
9	S	Quantify agriculture's contribution to nonpoint sources of pollution and devise innovative ways (physical) to control these sources.
9		Monitor water as a carrier of trace minerals and of chemical contaminants; study redesigning water treatment works to improve control of bacteriological and chemical contaminants.
14		Obtain additional information on the relationships of agricultural land uses, crop production, and conservation practices to nonpoint pollution.
14		Study technological and institutional alternatives for reducing exposure to schistosomiasis of people in large irrigation projects in the LDC's.
14		Analyze effects of strip mining and oil shale recovery on surface and ground water quality.

Rank Order		
		Quality of Water (continued)
18		Develop better systems to monitor nonpoint source water pollution and a better baseline for describing water quality.
20	SP	Develop ways to minimize or eliminate the nutrient enrichment of surface and subsurface water on both irrigated and nonirrigated lands.
20		Develop rapid screening methods for long-term effects of toxic substances in both man and the environment.
	S	Develop methods to rapidly identify and evaluate water pollutants and their sources and ways to renew water quality.
		Conservation and Use
4	SP	Determine timing and amounts of crop irrigation considering crop variety to more efficiently use water consistent with economic constraints, energy, and water quality.
6	SP	Find ways to improve irrigation water storage and distribution systems in order to increase water use efficiency and control water quality.
6	SP	Make more efficient use of water and nutrients, putting these necessities near the plant at a location for more efficient utilization.
9		Compare the contribution of channelization to agricultural production with its potential detrimental environmental impact on fish and wildlife habitat.
14	SP	Develop more accurate measurements of plant-soil moisture relationships and effects of irrigation timeliness.
18		Obtain additional information on the movements of water in soils as related to the kinds of soil, length and intensity of rainfall, vegetal cover, and slope.
20	SP	Investigate methods of capturing and retaining precipitation in arid and semiarid regions.
20		Conduct basic research involving water management, water stress, water loss, runoff and drainage control, top soil loss, and nutrient loss.

Rank
Order

Conservation and Use (continued)

S Determine more closely the effects of water on crop production.

S Find ways to improve water use efficiency on nonirrigated lands.

S Investigate the possibilities of recycling urban wastewater, including its quantity, quality, and economic potential for reuse in agriculture.

Resource Appraisal

9 SP Study the competition between a growing population and agricultural use of water to provide planning information for the best use of water.

S Determine the best use of Federal funds for soil and water conservation activities that will give the most economical increase in food production.

S Develop more intensive measurements of surface and ground water quality.

S Evaluate the contribution of alternate uses of water to society's goals and the best levels of investment and allocation among different uses.

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TABLE 2. Major Irrigating Countries, According to Amount of Irrigated Area.1/

Country	Year 2/		Cultivated area 3/	Irrigated area	Percentage irrigated
			----1,000 hectares----		percent
China (PRC)	1967	(1960)	110,300	75,980	68.9
India	1968		164,610	27,520	16.7
United States	1969		192,318	15,832	8.2
Pakistan	1969		19,235	12,505	65.0
USSR	1970		232,809	11,100	4.8
Indonesia	1969		18,000	6,800	37.8
Iran	1971		16,727	5,251	31.4
Mexico	1960	(1964)	23,817	4,200	17.6
Iraq	1970	(1963)	10,163	3,675	36.2
Egypt	1971		2,852	2,852	100.0
Japan	1970		5,510	2,836	51.5
Italy	1971	(1960)	12,409	2,444	19.7
Spain	1970		20,626	2,435	11.8
Thailand	1965	(1969)	11,415	1,830	16.0
Argentina	1968	(1959)	26,028	1,555	6.0
Turkey	1970	(1967)	27,378	1,549	5.7
Australia	1969		44,610	1,476	3.3
Chile	1965	(1964)	4,632	1,091	23.6
Peru	1971		2,979	1,116	37.5
Bulgaria	1971		4,516	1,021	22.6
Total 4/			1,457,000	203,600	14.0

1/ Includes individual countries having irrigated areas exceeding 1 million hectares.
2/ Year refers to year for which data on cultivated area apply: year in parentheses refers to year for irrigation data when different from year for cultivated area.
3/ Cultivated area is arable land plus land under permanent crops.
4/ Total and numerical values should be regarded as approximate because of incomparability of data between countries and different years of data collection.

Source: FAO, Production Yearbook, 1971, and earlier years.

3.3 WEATHER AND CLIMATE

Objective: To achieve understanding of weather and climate and related agricultural production in order to (1) develop policy decisions on farm production and food supplies, (2) preserve environmental quality and resources needed for food production, (3) ameliorate the effects of adverse weather, and (4) plan future plant and animal research.

SITUATION

Over the ages, weather and climate have exerted a profound effect on man's activities. With land, weather (the state of the atmosphere at a given moment) and climate (long-term atmospheric manifestations) are the principal environmental factors that determine the location of agricultural activity and the potential level of agricultural production.

The direct effects of adverse weather and climate on agriculture are obvious:

- Excessive precipitation can delay farm operations (planting, cultivation, harvesting) and destroy crops.

- Lack of precipitation or poor distribution over an extended time can cause tremendous crop losses.

- Extremes of temperature can reduce germination, hinder plant growth, and curtail development of those portions of plants used for food.

- Hail storms, extreme windiness, and other weather "incidents" can destroy crops and injure livestock.

- Indirect effects such as combinations of air temperature and moisture, if protracted, can create highly favorable conditions for the development and spread of disease and insect pests.

Over the longer run, adverse weather and climate can reduce environmental quality and the potential for agricultural production through such processes as accelerated soil erosion, excessive leaching, salt accumulation, and alteration of growing seasons. But weather and climate have a good side, too: Favorable weather can provide growing conditions that result in bountiful harvests.

There are several reasons why the effect of weather and climate on food supply has recently been receiving greater attention. First, adverse weather occurring simultaneously in several major agricultural regions of the world in 1972 reduced production and substantially lowered levels of food reserves. The situation has been compounded by the increasing pressures exerted by an evergrowing world population. Loss of the buffer provided by large grain reserves has created a situation in which food supply is much more sensitive to such variations as those caused by adverse weather.

The effects of adverse weather and a disadvantageous climate on agriculture can sometimes be reduced, particularly in the short term. Obvious examples are the use of heaters and wind machines in citrus groves to reduce frost damage and irrigation to ameliorate drought. Attempts to modify weather directly, using such means as cloud seeding, have produced inconclusive results. Modification of microclimate is in an early stage of development pending a more complete understanding of crop canopy microclimates. Shelterbelts and intercrops have demonstrated positive effects for small areas. Mulches can conserve moisture and modify seedbed temperatures.

Other types of technology also can be applied to maintain crop yields in the face of adverse weather and climate. Weather and climatic information can be used to select optimum operational and farm management techniques to minimize hazards. For example, fertilizer application and plant population density can be adjusted to avoid the adverse effects of weather.

Concern has been expressed recently that global changes in climate are in progress. The resultant shifts in temperature and precipitation patterns might have a major impact on world food production. Research in this phase of climatology and consequent food production is difficult because the worldwide scientific observation period is short relative to the trends involved, meteorological phenomena are affected by the complex interactions of many physical forces, and climatological data are often not sufficiently accurate. There is no general agreement on the direction or rate of change. If a major change were to occur over many decades or even centuries (an opinion shared by many), necessary adjustments might be made--for example, development of new plant varieties that tolerate water stress, temperature extremes, and shorter growing seasons.

The trend in climate, whether it be warming or cooling, may not prove to be of immediate concern over the next 10 to 15 years. Rather, the intra- and interseasonal variation in weather, which is a very real and immediate concern, may be the more important.

The extent of research in USDA and academic institutions that is directed to weather and climate alone (i.e., basic research in weather and climate) or that is focused on the weather-climate aspect of applied agricultural research is difficult to determine with precision. Weather and climate frequently enter research as an adjunct variable. For example, a study of tillage practices and wheat yields must include weather variables because plant canopy and soil environment are influenced by both tillage and associated weather.

Identified research programs and projects that include substantial man-hour inputs on weather-climate studies are carried out by universities in 36 States and at 28 locations of the USDA. An estimated 150 man-years are currently devoted to research in various aspects of weather and climate.

RESEARCH NEEDS

The following were identified as the important problems that require research related to weather and climate.

Rank Order		
		Resource Appraisal
1		Evaluate those areas where renewable resources can be optimally developed in relation to agriculture and food production.
2	SP	Develop a network to measure net radiation, soil moisture, soil temperature regimes by varied kinds of soils, humidity, ultraviolet radiation, and wind and report their implications for agriculture (transport of insects and diseases, wilting, etc).
4		Obtain more data on the characteristics of rainfall and runoff that affect soil erosion rates in the Southern and Western States.
7	SP	Measure the responses of animals and crops to weather, using simultaneously recorded biological and environmental data.
12	SP	Determine present and future needs for data on climate; assess data presently available from sources such as NASA; develop techniques and instruments to collect needed data, summarize it, and make it available for agricultural forecasts.

Rank
Order

Resource Appraisal (continued)

17 Develop modeling techniques to accurately forecast the need for (and estimated end results from) long-range varietal selection, tillage method-"solutions," and the processing, preservation, and storage-energy requirements, all well ahead of time of need for large increases in electrical energy.

S Study crop, weather, and soil patterns over wide geographical areas to determine whether variety tests and other research data can be used in various parts of the area.

S Survey soil moisture and plant water deficits in farm areas where soil moisture reserves may limit farm production.

Climatic Stress

3 SP Evaluate plant canopy design (canopy modeling) as a way to improve crop use of carbon dioxide and solar energy.

4 SP Develop methods of production, based on complete climatic conditioning, that overcome or reduce weather stress (irrigation, windbreaks, intercropping, animal shelters, etc.) with corresponding assessments of energy use data. Data should be sufficiently complete to readily transfer and translate results to broad and different areas of the United States.

8 SP Make a critical evaluation of the extent of practical use of solar energy for thermal heating of livestock and human structures and for crop processing practices, keeping in mind the end or net effect upon electric energy supplier's load factor and future costs of electric energy for food production and processing.

12 SP Identify important characteristics that confer resistance to weather stress.

15 SP Breed plant varieties and animals with stress resistance.

Rank Order

Microclimate Modification

4 SP Develop models to predict effects on plant and soil microclimates of (1) inadvertent and deliberate changes in the weather or climate and (2) management inputs such as tillage and disposal of plant residues.

9 SP Develop cultural methods such as vegetative mulches and windbreaks to change microclimates and reduce plant stress.

9 SP Investigate control of evapotranspiration to increase available plant water supply.

12 SP Investigate the roles of radiation, heat, water, carbon dioxide, and chemicals at (1) the soil surface, (2) within plant canopies, and (3) at the upper surface of the plant canopy.

19 Develop and/or establish the optimum total-energy-use factor (in BTU's ft/degree/day/year or its metric equivalent) for rural family housing based on specific degree-day differentials. (Note: Same type of problem applies to rearing livestock in confinement shelters.)

S Extend the technique of plant canopy modeling to more complex systems such as row crops and intercrop systems.

S Develop more knowledge to predict wilting, disease, and insect outbreaks caused by weather.

Weather and Climate Changes

11 SP Determine the probabilities over time of unfavorable weather in each of the major producing and importing regions of the world and the probabilities of simultaneous unfavorable weather in a number of regions within a given year or in consecutive years including archeological and geological studies.

15 SP Identify agricultural production practices based on favorable weather during the last decade or two and identify the changes that may be needed to adjust agriculture to a more variable, less favorable climatic period, estimating and/or forecasting corresponding energy input/energy output data.

Rank
Order

Weather and Climate Changes (continued)

20 SP Determine the probabilities of short- and long-range changes in climate for major areas of arable land.

S Learn more about climate and weather changes caused intentionally or unintentionally by man--such as urban climates, particulates in the atmosphere, etc.

S Use weather-soil-plant productivity concepts to estimate plant performance under changed climatic conditions.

Weather Modification

17 Evaluate the possibilities for weather modification and its physical, economic, environmental, social, legal, and other implications.

3.4 ENERGY

Objective: To ensure an economical and adequate supply of food by increasing the efficiency of energy use and developing substitutes for oil and mineral fertilizers in the production, marketing, processing, and use of foods.

SITUATION

Agriculture is concerned with energy in two respects. First, it is engaged in the conversion and storage of solar energy through photosynthesis into products useful to man. Food is the dominant and most important of these. Second, agriculture is a user of other forms of energy in bringing about that conversion. Several forms of energy external to the photochemical process are used, including fuels for tractors and other machinery, electrical power to drive motors for a variety of uses such as irrigation, and energy for the manufacture, distribution, and application of fertilizers or other chemicals. For convenience these forms are referred to as cultural energy (2).

Growth in the use of cultural energy generally has been justified on the basis of economic efficiency, substituting relatively low-cost energy for higher cost labor and animal inputs. In the United States in 1930, there was one farm worker for every 10 people in the nonfarm population; in 1971, there was one worker for every 48 people (3). Some of these nonfarm people provide supplies and services to farmers, some of which are energy intensive. Draft animals on U.S. farms have declined from 22 million in 1920 to practically none today (2), thus illustrating the substitution of fossil fuel energy for that produced annually as feed for draft animals.

In 1972, total energy use in the United States was equivalent to 36.5 million barrels of crude oil per day, in the form of hydropower, nuclear energy, natural gas, and fossil fuels. The food system is estimated to account for only 12-15 percent of total energy use, compared to the transportation industry (25 percent) or the commercial space heating industry (18 percent). Of the portion used by the food system, the distribution by function is as follows: (1)

Function	Percent of total	Million barrels equivalent per day*
Agricultural production	18	1.1
Food processing	33	2.1
Transportation	3	.2
Wholesale and retail trade	16	1.0
Household preparation	30	1.9
	100	6.3

*Based on the midrange of the estimate of food system use.

As shown in the table, transporting, processing, packaging, distribution, and home preparation of food use more than 80 percent of the energy input for the food we eat. The large proportion consumed in these uses suggests opportunities for energy saving.

The major amount of energy used for agricultural production is in the form of fuel, followed by fertilizers, metals and machinery, electricity, pesticides and chemicals, and animal feed (2).

Total energy use in the United States has been increasing at the rate of about 10 million barrels of crude oil equivalent per day about every 6 or 7 years. This rate has been projected as continuing or possibly increasing at least through 1990 (4).

Total energy inputs into the food system in the United States have been increasing at a much faster rate than the amount of food energy consumed. Total inputs have nearly doubled since 1950 with the largest increases coming in the commercial and home preparation sectors of the food system. All sectors increased much more rapidly in energy used during the 1960's than the 1950's. Most components of the food system approximated the general rate of increase. Two notable exceptions were tractors which decreased energy use by a third from 1950 to 1970 (largely because of the increase in self-propelled farm machinery), and transport fuel which more than doubled.

The U.S. system for producing, processing, marketing, and using food and fiber is typical of our energy-intensive society. Elements of the system rely heavily on substitution of energy for human and animal efforts. In conjunction with other factors such as new crop varieties and animal breeds and improved cultural and management practices, the success of the system has been attained mainly through the increased use of energy. This increase has resulted in greater unit productivity, a wide spectrum of wholesome and nutritious consumer products, and the release of a major portion of our population from menial, tedious, and economically unrewarding tasks.

While adjustments may be made in current methodology involving the use of energy in our food and fiber system, the margin of adjustment is narrow and the resulting small savings would have little influence on alleviation of energy shortages. At the same time, such adjustments would create the potential for a serious disruption in the supply of food. The challenge is to develop new technology and methodology leading to more effective use of renewable and nonrenewable energy resources that will not adversely affect the productive capacity of the system.

Gross figures describing cultural energy efficiency are somewhat misleading. As mentioned earlier, the cultural energy needed for producing, delivering, and preparing food is in the form of fuel, electricity, machinery, fertilizers, chemicals, and animal feeds. In general, only about 16 percent of this energy is returned as chemical energy in the food. However, this figure varies widely. It is as much as 37 percent for sugar and as little as 5 percent for vegetables.

Data suggest that: Further gains in replacing labor by conventional forms of cultural energy may be considerably limited. The long-term trend in requiring more calories of input per calorie of output is not abating. Energy conversion in agriculture is susceptible to a growth curve phenomenon, which means that additional energy will have to be relatively cheap if it is to be used--a condition that does not exist in fact.

Another study indicates that for a significant number of crops an increase in cultural energy of as much as 50 times results in only a two- to threefold increase in digestible energy obtained per acre (2). More primitive agricultural systems, those based on human power, can produce 16 calories of digestible energy per calorie of cultural energy while animal-based systems produce only 3 to 6 calories and modern machine-intensive systems only 5 calories of digestible energy per calorie of cultural energy. On the other hand, although the Philippine rice culture, for example, is one of the most energy-efficient cropping systems, it is also one of the least efficient as far as digestible energy <u>per acre</u> is concerned. Only 6 people per acre can be supported by this system while 17 people per acre can be supported by the relatively high-energy cultural techniques in use in the United States. The crops used by different agricultural systems affect energy-use comparisons of those systems.

In the short run, we may be limited in how far we can adapt to changing energy use patterns. One estimate suggests agricultural production probably could absorb easily a 15-percent reduction in energy through more efficient use (1).

In the long run, major changes will occur in production practices to: Conserve energy. Use more abundant form of energy (generation of electricity with coal and nuclear materials). Make greater use of solar and wind energy. (Reductions in packaging of foods would also conserve energy.)

World Situation

In essence, the energy problems of the world's hungry nations may be no different than those of the industrialized countries--simply more intense and more imminent. All the free or cheap labor in the world will produce only so much on a given area of land. Somehow, the world's land area must be enlarged and made to yield more per unit.

It should be apparent that the food system in this country cannot necessarily be replicated in developing countries. For one thing, there simply would not be enough energy to go around. Even based on the relatively efficient cultural and energy conversion of corn, it still would require about 1.4 acres per person and 80 gallons of crude oil equivalent for each of the approximately 4 billion population, or about 488 billion gallons of crude oil equivalent per year (3).

A second, frequently forgotten factor is that the extremely complex food system in the United States is an inextricable part of the overall industrial system of the country. Few aspects of the system can exist for long outside it. The use of superior food crop varieties appears to provide one means for increasing output of digestible energy per unit of land, but to be successful it will require high energy inputs. In the presence of inexpensive energy sources, this was less of a problem. As energy prices continue to climb relative to income, it may become serious. Developing countries have fewer nonagricultural resources available to provide solutions to such problems. They are forced to rely in part on solutions developed by industrial nations which, as has been evident in recent years, must be tested and adapted if they are to be useful.

RESEARCH NEEDS

The following were identified as the important problems that require research related to energy.

Rank
Order

Increasing Efficiency of Energy Use

(These research needs are presented in other sections)

Rank
Order

Alternates and Substitutes

Rank		
1	SP	Develop uses of nuclear energy including fusion.
2	SP	Develop and improve the technology and use of solar energy separately in conjunction with other forms of energy for heat and power.
3	SP	Increase use of agricultural wastes and other sources of biomass as power and heat sources.
4	S	Determine equipment performance requirements for energy conversion, in order to provide satisfactory components for food systems.
4	SP	Increase heat storage efficiency and capacity to use waste heat.
4		Determine ways to recycle wastes. Destruction of all types of used products wastes our energy resources as well as contributes to environmental contamination.
7	SP	Evaluate the impact an energy tax or energy allocation systems would have on food supplies.
7	S	Develop methodologies to evaluate the impact on agricultural production of transferring water from irrigated agriculture to energy development.
9	SP	Increase use of renewable organic fertilizers and nitrogen fixation and more efficient use of nitrogen fertilizer.
9	S	Develop low-energy culture systems for food production and improved technology for small-scale agriculture.
9		Develop food processing methods using less energy intensive materials--fiber, paper, foil, plastic, plastic films.
9		Identify agricultural production and processing practices that will allow for ready substitution of electric energy for operations now using nonrenewable resources. Determine the extent of such substitution, Statewise and nationally, so the electric energy industry can more adequately plan plant construction for use in future food production, processing, and distribution 10 years hence.

Rank
Order

Alternates and Substitutes (continued)

9 Determine the impact of varying levels of energy costs on the economic attractiveness of land-conserving technologies (ground water irrigation, heavy per acre use of fertilizers and pesticides) relative to land-using technologies (dry land farming, relatively light per acre use of fertilizers and pesticides).

14 SP Obtain more data on the energy used by the food production, processing, marketing, and consumption system, in order to suggest improvements, assess the impact of national policies, determine the effects of alternative practices, and establish research priorities.

14 Determine implication of surface mining and shale development for agricultural land use and production.

14 Evaluate the impact of soil and water conservation management systems on energy requirements for food and fiber production.

17 SP Develop and improve uses of wind for power.

17 Study ways to improve productivity of existing oilfields--60 percent of the oil remains unavailable and in the formation.

19 Investigate ways for greater use of hydrogen-storage transport, prime movers.

20 Develop "all-energy-use" predictive models that will forecast the interrelationships of factors affecting food production as these apply to quantitative and qualitative characteristics such as electric energy, petroleum products, fertilizers, field and farmstead machine type and size, structures, processing methods, climatic conditions, and labor inputs.

20 Determine the indirect costs to the production, processing, distribution, and consumption of food due to costly pollution abatement equipment, restraining regulations on the optimum use of chemicals, and/or on excess safety regulations.

20 Investigate potential increased pollution of water and air as a result of strip mining and other mining and manufacturing processes undertaken because of petroleum shortages.

Rank
Order

Alternates and Substitutes (continued)

20 Determine ways to improve resource productivity (i.e., reducing the nonrenewable inputs per unit of output) by minimizing waste and by reducing materials input per unit of output.

20 S Increase use of coal in providing food supplies.

S Develop cheaper means of storing energy, particularly from sources with varying output and for uses with varying requirements.

S Develop multicommodity systems to make more efficient use of energy.

S Investigate the possibility of reducing energy requirements by optimizing the geographic structure of agriculture.

S Investigate the use of heat from power generators especially stationary electricity generation plants.

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Objective: To develop production, management, marketing, and utilization practices to assure an adequate supply of wheat for U.S. needs and a stable supply for export markets, while conserving resources and environmental quality, and to improve nutritional and processing quality.

SITUATION

The World

Expanding and upgrading world wheat production must be given top priority in any research effort aimed at easing the world food problem. While more than two-thirds of the world's 360 million metric tons of wheat production is now concentrated in 5 major producers--the U.S.S.R., the United States, the EC-9, China, and India, some wheat is grown in or exported to every region of the world. Direct food consumption of wheat currently accounts for about a fifth of the world's total caloric intake, and wheat accounts for about 10 percent of the grain fed to livestock.

With world population increasing at about 2 percent per year, wheat production will have to reach 430-435 million tons by 1985 just to maintain current per capita food consumption levels. Income growth is likely to lead to higher per capita consumption levels and an accelerated shift away from rice and coarse grain diets toward wheat in the developing countries and more wheat feeding in the developed countries. Given continued increases in wheat area and yield comparable to those of the past two decades, USDA projections of combined 1985 wheat food and feed demand of 450 million tons seems reasonable.

Expanding wheat area harvested does not appear to be a production constraint. The 220 million hectares currently harvested account for about a third of the total grain area or about a fifth of the total area cultivated. Wheat area harvested has expanded at an annual rate of 0.35 percent or roughly 6-8 hundred thousand hectares a year over the past two decades despite continued efforts by the major exporters, particularly the United States, to reduce grain area. Growth in the developing countries, where a conscious effort has been made to expand wheat area even at the cost of squeezing out other grains, has been about 2 percent or 8-9 hundred thousand hectares per year. Continued expansion of area at even the lower 0.35 percent world rate over the next 10 years would account for about a fifth of

the added production needed to balance projected world demand.

Much more work is necessary in the area of yields. World wheat yields, currently averaging 1.75 metric tons per hectare, have increased by about 3 percent per year despite the major exporters' emphasis on expanding (or contracting) area rather than yield to increase (or decrease) production. Yields in Western Europe, where land resources are limited and high support prices have encouraged maximum output, have increased by about 3.7 percent per year to their current peak of 3.25 tons per hectare. Wheat yields in the developing countries, currently averaging 1.2 metric tons per hectare, have increased at the slightly lower rate of 2.7 percent per year. Analysis indicates that continued growth at the world rate of 2.0 percent per year necessary to reach the 450-million-ton projection is within reason well beyond 1985.

Much of this increase in yields depends on expanding research designed to speed the transfer of agricultural technology and the adaptation of existing technology to the needs and resource availabilities of the developing countries. Above and beyond the technical research necessary to realize the production potential of improved inputs and early-maturing, high-yield, disease-resistant varieties is the economic research necessary to improve farm management practices. Much thought also must be given to the implementation of agricultural food policies that encourage use of the best available bundle of physical inputs. Considerable effort is also needed to improve local procurement, marketing, and distribution systems and to reform food and agricultural policies. Without increased effort in all these areas, maintaining production growth rates comparable to those of the past 15-20 years will be difficult.

The United States

Wheat usually ranks second among U.S. grain crops in total acreage harvested. In 1974 it ranked first, slightly exceeding the acreage of corn harvested for grain. The total harvested acreage of wheat in the United States during the past 10 years has ranged from 44.1 million acres to 65.5 million acres. In this century, the smallest acreage was 43.2 million acres in 1902 and the largest was 75.9 million in 1949. Two other years of record large acreages of wheat were 1919 and 1947--following World Wars I and II and a series of years of relatively high prices. Our capacity to produce wheat greatly exceeds the domestic demand; consequently, wheat is an important commodity in our exports.

In many of the years since the 1930's, the acreage of wheat grown in the United States was restricted by Federal farm programs aimed at holding down market supplies and supporting prices received by farmers. Despite the Government programs, wheat production trended upward from the middle 1930's, reaching a record high of 1.7 billion bushels in 1973 and 1.8 billion bushels in 1974.

Most of the increase in production of wheat in the United States during the past 50 years has come from higher yields. Some of the increase resulted from the dropping out of relatively less productive land as acreage was reduced. Average yields per acre have tended to increase persistently although in many individual years they have been below the trend because of diseases, drought, or other adverse conditions. The lowest annual average yields in this century were recorded in the drought years of the 1930's, ranging from 11.2 bushels in 1933 to 12.8 bushels in 1936. Since the 1930's, the U.S. average yields of wheat have increased by about 3 to 6 bushels each decade. The range in average yields during the past 10 years has been from 25.8 to 33.9 bushels. The higher yields have resulted from more widespread use of improved varieties, greater use of commercial fertilizer, more effective and timely cultural operations, better weed control, and relatively favorable weather. The past 50 years have witnessed great strides in seed improvement, in development and adoption of chemical fertilizers and pesticides, and in improved farm machines and power units--all of which, along with improved management, have contributed to higher levels of yields.

Most of the wheat produced in the United States is grown in the Great Plains region. Six of the States in this region produced 61 percent of our total wheat crop in 1973. About 14 percent was grown in the three Pacific Northwest States. In these two regions, wheat is generally the major crop on the farms where it is grown. Because of the semiarid climate, a common practice in the northern and western parts of the Great Plains is to grow wheat on the land only once every 2 years. In alternate years, the land is left fallow but is cultivated to kill weeds and conserve moisture for the next year's wheat crop. Yields often vary by 25 percent or more from year to year because of variations in the supply of moisture available.

Wheat is grown on many farms in other regions of the country also, but not generally as the major crop. Mainly, these regions are the southern and eastern Corn Belt, Mississippi Delta, Atlantic Coast States, and California.

The many varieties of wheat grown in the United States are generally grouped into five market classes: hard red winter, hard red spring, soft red winter, white, and durum. The largest class in terms of quantity produced is hard red winter wheat. This is by far the dominant class in the Great Plains region as far north as South Dakota and is also the main class in Montana. Hard red spring wheat is produced largely in North and South Dakota, Minnesota, and northeastern Montana. Soft red winter wheat is the principal class grown in the Corn Belt, Delta, and Altantic Coast States. Production of white wheat occurs in Washington, Idaho, and Oregon, with scattered production in other far western States and in Michigan and New York.

Durum wheat is produced mainly in North Dakota with the production area extending into western Minnesota, northern South Dakota, and Montana.

During the past 10 years, about half the wheat produced in the United States has been exported. Domestic use has ranged from 700 to 855 million bushels annually. Two-thirds to three-fourths of the domestic disappearance has been for food (flour and other food products). The rest has been used for seed and feed. Millfeeds amount to about 25 percent of all wheat milled. Use for seed has generally taken less than 10 percent, while use for feed has ranged from 20 to 30 percent. The total quantity used for food has been relatively stable, increasing slowly with population growth. Use for feed is affected by the price of wheat relative to other feeds and the prices of livestock.

United States wheat and wheat products are exported to countries in all parts of the world. Some of our largest customers in recent years have been the Republic of China, Japan, the U.S.S.R., India, Korea, Taiwan, Brazil, Algeria, and the Netherlands. The principal wheat exporting countries with which the United States must compete in world markets are Canada, Australia, Argentina, France, and the U.S.S.R.

Among factors that impair or limit wheat production in the United States are adverse weather (heat, drought, hail, winter killing, wet fields at seedtime and harvest), soil erosion, weeds, diseases (rust, smut, etc.), and insect pests affecting the growing crop and the stored grain. Economic factors that affect wheatgrowers' plans include prices of wheat relative to prices of other crops and livestock and to the cost of production; financing of farm operations; availability of power, fuel, machine parts, and fertilizer; availability of suitable land for farm enlargement; and quality of local marketing facilities.

RESEARCH NEEDS

The following were identified as the important problems that require research related to wheat.

Rank
Order

Production

1 SP Minimize genetic vulnerability to environmental stress, insects, disease, nematodes, and weeds.

2 SP Develop genetic resistance to major disease, nematodes, and insects.

Rank Order		
		Production (continued)
3	SP	Produce wheats better adapted to growing conditions, particularly via improved winter hardiness, drought tolerance, and seedling vigor.
4	SP	Collect and maintain a stockpile of wheat germplasm so that new genetic combinations can be made.
5	SP	Expand research on intergeneric hybrids, including cell genetics and tissue culture techniques.
6	SP	Investigate host-pest interactions and plant resistance to pests and environmental stress.
6	S	Investigate the nature of winter hardiness in wheat.
9		Reduce the enormous loss to pests, disease, and deterioration in poor storage through integrated systems of coordinated research of genetic, biological, cultural, and chemical control of pests and disease.
9		Determine ways and means to reduce energy consumption in wheat production and to use alternative (to fossil fuel) sources of energy, such as solar energy.
12		Undertake a research program to identify the major factors, internal and external, which limit wheat yield and quality.
13	S	Develop additional methods for crop improvement, including protoplast hybridization.
14		Develop new production systems which use fossil energy more efficiently.
16		Study host-pest relationships and develop techniques for use in breeding programs (diseases and insects).
18		Expand genetic vulnerability studies. Assess present situation and monitor problem.
19	SP	Develop tests to rapidly screen germplasm collections for genetic variations in grain.
19		Study species building, wide crosses and their yields, disease and insect characteristics.

Rank Order		
		Production (continued)
	S	Investigate the nature of drought resistance.
	S	Improve the photosynthetic capability and efficiency of wheat plants, in order to increase use of solar energy and improve yields and quality.
	S	Explore the possibility of developing nitrogen-fixing capacity in wheat.
		Marketing and Processing
9		Identify future needs for the distribution of wheat, wheat byproducts, products from wheat, and inputs such as fertilizer and fuel so that appropriate plans can be developed to meet these needs.
17	S	Improve transportation systems for moving wheat from farms to markets.
19	S	Determine the impact of U.S. marketing policies on the competitive position of American wheat in foreign markets.
	S	Develop methods of promoting export sales.
	S	Evaluate possible new freight rate structures that would not unduly increase marketing costs.
	S	Determine wheat uses and requirements of foreign customers.
	S	Develop a more efficient information system on export sales.
	S	Update grain standards and revise grain sanitation procedures.
		Consumer Needs
6		Develop a national food policy that establishes national food goals.
14		Determine relation between human needs by agricultural products and capability of American agriculture to produce foods and fiber to meet these needs, in two phases: (a) domestic and (b) world.
	S	Continue and expand efforts to increase protein quantity and quality.

Objective: To develop production, marketing, and utilization practices that will assure adequate supplies of rice for domestic and foreign markets that now exist or can be developed, while minimizing loss of resources and environmental quality.

SITUATION

The World

Significant improvements in the diets of the 2.7 billion people that live in developing countries depend largely on accelerating growth in indigenous rice production. Rice currently accounts for as much as three-fourths of the total caloric intake of the 1.9 billion people living in Asia and up to a third of the caloric intake of the 0.8 billion people living in Africa and Latin America.

World production of rice has risen by about 2.3 percent per year over the past two decades. While the African, Latin American, and U.S. crops have increased sharply, particularly over the past 10 years, more than 85 percent of world production is still concentrated in the noncommercial subsistence farming areas of Asia. Less than 5 percent of the world rice crop moves in international trade; virtually all of the rice produced in Asia, with the exception of a small part of the Chinese and South Asian crop, is produced and consumed locally.

Population growth has kept increases in world per capita rice production small while actually lowering per capita levels in densely populated South Asia. Maintaining current per capita consumption levels of roughly 90-100 kilograms in Asia alone would require a crop of 265-270 million tons (milled) by 1985. FAO world demand projections, providing for population growth as well as income growth and further substitution of lower priced wheat for rice, set 1985 demand at 290-300 million tons. The growth in rice production needed to reach these levels will most likely be spread over Asia, Africa, and parts of the Western Hemisphere.

Growth in production over the past two decades has been due to increases in area of about 1 percent or 1.2-1.3 billion hectares per year and to yield increases of about 1.3 percent per year. An increasingly larger proportion of future growth will quite likely result from improved yields rather than from expanded area. The heavy investment needed for larger scale land reclamation, water control, and resettlement schemes will most likely keep area expansion

at or below its current trend rate. Progress in raising yields from their current level of 1.3 metric tons (milled) per hectare will be slow at first. Current low yields in the developing countries where rice production is concentrated are due to a combination of the primitive technology, poor seeds, little fertilizer, and inadequate water control. The bulk of the scientific research necessary to improve average yields has been developed in the United States and in agencies such as the International Rice Research Institute at Los Baños in the Philippines.

Analysis indicates that yields of 2.0-2.5 metric tons (milled) per hectare on a world basis are possible with wider adoption of existing technology. Additional research is needed to raise yields above the plateaus reached in many of the developed countries.

Above and beyond accelerated adoption and expansion of modern rice technology is the problem of increasing investment in local agricultural infrastructures. Improved water control is needed to lessen dependence on uncertain rains. Improved procurement, drying, storage, and distribution systems and facilities are necessary if increases in country production are to reach urban centers without the losses currently estimated at 20-25 percent of the entire crop.

Combined efforts in both these fields--broadening use of modern technology and greater investments in infrastructure--should make possible the growth in production needed to reach the 300-million-ton level by 1985.

The United States

Rice is a relatively minor grain in the United States in terms of the volume produced and the acreage used for its production. But the high unit value of rice places the value of the crop ahead of barley, oats, and rye. Additionally, the relatively small area of the United States for which rice is a suitable crop make it an important commodity in those areas. Production of rice is restricted primarily to four South-Central States and to sections of California having soils and water resources and economic circumstances particularly suited to rice production. Very minor quantities are produced in other States.

In the past two decades, marketing quotas and acreage allotments imposed under price support legislation have been major factors influencing rice production. From 1955 to 1973, the acreage seeded was determined largely by the allotments, which varied from 1.65 million acres, the minimum acreage as specified by law, to 2.40 million acres. The acreage actually seeded ranged from 1.37 million in 1957 to 2.37 million in 1968. Production ranged from 2.15 million

tons in 1957 to 5.20 million tons in 1968. Marketing quotas were not imposed for the 1974 crop, and with prices at record levels, producers expanded plantings to 2.59 million acres. Production, at about 5.70 million metric tons, also was a record in 1974. Yields have increased by about 2,000 pounds per harvested acre since the early 1950's.

All three types of rice--long, medium, and short grain--are produced in the United States. About 50 percent of the production is long grain, 40 percent is medium grain, and 10 percent is short grain.

The export market is the predominant outlet for United States rice production. The United States produces only about 1.5 percent of the world crop, but it is a major supplier of rice in international trade. Much of the export volume has been dependent on Government assistance since prices in the United States historically have significantly exceeded prices in the world markets. Export subsidies have been used to make United States rice competitive in world markets. Large volumes also have been shipped under PL-480 and AID programs. Recently, scarce exportable supplies in the world have caused prices to increase substantially and the United States has been able to compete in commercial markets.

Per capita consumption of rice has remained relatively constant in the United States, averaging between 7 and 8 pounds since 1960. Much of the increased domestic use of rice in recent years is attributable to population increases. About 65 percent of this consumption has been for direct food use, 15 percent in the form of processed food products (cereals, soups, etc.) and 20 percent has been used by the brewing industry (mostly broken grains).

Given attractive prices for rice relative to competing crops such as soybeans and cotton, there is a potential to expand rice acreage in the United States. Available water supplies and practical rotation programs restrict the potential acreage to about 4 million acres, although there is more land suitable for growing rice. Another restriction is the lack of adequate processing facilities. Evaluation of some alternatives, assuming projected demand levels for rice and prices of competing crops, indicates that seeded acreage up to 3 million acres is possible during the next few years. This would be an increase of about 15 percent over the acreage seeded in 1974. Expansion to the higher acreage levels would require a good long-run outlook for profits to induce producers to make the investment needed to prepare land for rice production and to purchase special machinery. Additional investment in drying, milling, processing, and storage facilities also could be required for significantly expanded acreage. The United States still would be a relatively small part of the total world picture, although its importance in international markets could be expanded.

RESEARCH NEEDS

The following were identified as the important problems that require research related to rice.

Rank
Order

Production

1 SP Breed new high-production, high-quality varieties that tolerate such hazards as disease, insects, and cool temperatures.

1 Develop varieties that are shorter in stature, resistant to lodging, earlier maturing, resistant to blanking (floret sterility), and have good cooking quality, good flavor, and higher protein content.

3 SP Develop improved tillage equipment and methods to (1) reduce energy use and costs and (2) dispose of crop residues with minimum harm to the environment.

4 SP Develop improved screening techniques for locating sources of resistance to major rice diseases, including stem rot and other stem diseases.

4 Improve methods for aquatic weed control.

6 SP Develop adapted commercial rice varieties with a broader genetic base to increase resistance to major production hazards.

6 Devise more economical methods for the removal and utilization of rice straw and hulls.

8 SP Develop improved varieties of all three major grain types with shorter growing periods, in order to facilitate double cropping and increase output.

9 SP Develop improved pesticides and application equipment that will minimize potential damage to adjacent crops and the environment.

9 SP Study the genetic, physiologic, and morphologic factors that determine grain yield.

11 SP Develop new, nonchemical approaches to control of rice weeds, insects, and diseases.

Rank Order

Production (continued)

12 SP Develop ways to reduce the amount of water needed to produce rice, including suitable varieties with shorter growing periods.

13 Develop means for improving rice stands by cultural, breeding, or seed treatment processes including chemicals that stimulate seedling vigor.

15 SP Develop methods for reducing fertilizer nitrogen losses and increasing nitrogen utilization by the plant.

15 SP Investigate effects of adverse microclimate and find ways to reduce its damage, such as floret sterility.

15 Develop engineering systems from field to distribution that reduce costs and energy requirements.

18 SP Determine more fully the mutual effects of rice diseases, fertilization, and other cultural practices.

18 Investigate water runoff quality standards and procedures to meet environmental requirements.

20 Investigate soil management practices to maintain and improve lands cropped continuously to rice.

S Improve efficiency of solar energy conversion in rice.

S Study the root growth of rice plants and the chemistry of flooded soils in order to improve soil conditions for growth and yield.

Develop improved methods of selecting potential yield and resistance-increasing factors.

Marketing and Processing

14 S Improve drying processes for maximum quality with reduced energy requirements.

20 S Improve storage methods to prevent damage from insects and microorganisms.

20 SP Develop ways to increase milling yields.

Rank
Order

Marketing and Processing (continued)

S Investigate ways to increase the market for lower cost, nonpremium, high-yielding varieties of short grain rice.

S Develop alternative ways of carrying U.S. rice stocks from years of world plenty to years of shortage.

Consumer Needs

S Develop varieties with a higher protein content.

4.3 CORN

Objective: To develop production, marketing, and utilization practices to assure an adequate supply of corn for U.S. livestock needs and for human food at home and abroad, while conserving resources and environmental quality.

SITUATION

The World

Continued growth in corn production is necessary if the food and feed demands of a larger, more affluent world are to be met. Reaching a record 310 million tons in 1973, world corn production has risen by 3 percent per year during the past two decades to rank second only to wheat in terms of kilograms produced per capita. Much of this increase in production has been concentrated in the Western Hemisphere, but corn cultivation is expanding rapidly in the Eastern Hemisphere--particularly in East and Southeast Asia.

World corn area has expanded at about 1 percent, or a million hectares per year, since 1955 to its current peak of 116 million hectares. Corn's adaptability to a wide range of growing conditions makes continued or accelerated expansion of area, often at the expense of lower yielding coarse grains, quite likely. Yields have grown by more than 2 percent per year during the same 20-year period to their current level of 2.7 metric tons per hectare, or roughly 150 percent of the average yield of all grains.

The world corn crop is made up of two different types of grain. Feed corn, generally yellow or reddish in color and coarse and hard in texture, is grown in the major grain surplus countries and consumed domestically or exported to other high-income countries, but for use in livestock feeding in either case. The largest yield increases to date have been concentrated in yellow corn. Averaging about 5 tons per hectare, yellow corn yields in the major exporting countries have grown by more than 3 percent per year due to extensive hybridization and rapid adaptation of related technology. Area planted to yellow corn has expanded by about 1.8 percent (4-5 hundred thousand hectares) per year despite the large proportion of yellow corn grown in countries that have implemented area controls. Precise data is not available, but estimates set yellow feed corn's share of total corn production at 55-60 percent.

White corn is generally grown in the grain-deficit developing countries and is used, along with some yellow corn, as a food staple. The areas of the world most dependent on white corn are the Caribbean,

Central and South America, and Central and East Africa--precisely those areas where per capita incomes are too low to finance any large move into higher cost wheat and rice. Little white corn enters the international market. A large part of the crop is produced and consumed locally with a small share entering national markets. White corn yields have grown about 0.8 percent per year over the past 20 years to a current level of 1.2 tons per hectare. Area has expanded about 1.25 percent (5-6 hundred thousand hectares) per year.

Corn's role in easing long-term world food shortages depends largely on the income situation in the developed and developing countries. Corn is expected to account for two-thirds of the 830 million tons of coarse grain production projected by USDA for 1985 compared with roughly half of the 1969-71 total of 535 million tons. If the developing countries continue to eat an essentially cereal diet, feeding little if any corn to livestock, and if depressed income growth in the developed countries dampens demand for corn-fed livestock products, then sustaining the production growth rates of the past 20 years would be sufficient to meet world demand. But if improved income growth generates expanded feed demand in the developed countries and stronger food and feed demand in the developing countries, production will have to be expanded by as much as an additional 50 million tons.

Realizing this accelerated growth depends on extensive research efforts aimed at improving yellow corn technology and adapting existing technology to white corn. Much of the technical work has been done. Raising yields in the developing countries to half the level of U.S. yields would produce enough corn to more than meet combined food and feed demand under the most optimistic income assumptions. The practical problems of encouraging local adaptation of updated technology and improved inputs and developing effective local procurement and marketing systems to handle increased production are yet to be solved.

The United States

Corn ranks at the top among American grain crops--in acreage, in tonnage, and in total value of production. Even so, the acreage is much smaller than it was 40 years ago. From a record high of 97 million acres in 1932, the land area of corn harvested for grain was reduced in response to Government farm programs and reached a low of less than 55 million acres in 1969. It then expanded to 65 million in 1974. Because of the persistent increase in yields, total production continued an upward trend since the 1930's and amounted to 5.6 billion bushels annually in 1971, 1972, and 1973.

In 1974, for the first time in four decades, there were no Government program restrictions nor inducements to hold down the acreage of corn. Total planted acreage of corn increased 8 percent in 1974 over 1973 (16 percent over 1972). But corn production in 1974 (4.7 billion bushels) was much smaller than in the three preceding years because of low yields due to adverse weather (prolonged spring rains, drought, and early fall frost). The 1974 average yield per acre was 71.3 bushels, the lowest for any year since 1964.

Average yields per acre, at 20 to 26 bushels in the early 1930's, increased to 53 bushels in 1958 and 1959 and continued to climb to 97 bushels in 1972, nearly a fourfold increase in 40 years. This tremendous improvement in yields was made possible by generally favorable weather, by continuing development of higher yielding hybrid varieties, and by continued improvement in growing and harvesting technology (including heavier fertilization and more effective weed and insect control). Some of the increase in yields resulted from the retention of the relatively more productive land for corn as the total acreage of corn was reduced in compliance with Government programs.

The major region of corn production in the United States is the North Central Region, centering in Iowa, Illinois, and Indiana, and including adjoining States. For the past 3 years, the leading States in corn grain production have been Iowa, Illinois, Nebraska, Indiana, and Minnesota. These five States produced 62 percent of our total corn grain in 1974 and 67 percent in 1972 and 1973. But corn is grown throughout the country, and in 1974 there were 24 States with production exceeding 20 million bushels.

Much corn acreage is harvested for silage and additional acreage is sometimes harvested as silage or fodder on dairy or beef farms in years when an early fall threatens maturity of corn intended for grain. Silage production is most prevalent in the northern States, but this use of the corn (mainly as feed for dairy and beef cattle) is important throughout most of the Nation. For the past 3 years, 12 to 14 percent of the total planted acreage of corn has been harvested as silage.

During the past 10 years, about 40 to 50 percent of the corn produced has been used for feed on the farms where it was grown. The remainder, except for a very small quantity kept for seed, has been sold. Most of the corn sold has also been used as domestic livestock feed, so the total used for feed has generally been 75 to 85 percent of the crop. The next largest use has been for exports, which have generally taken around 12 to 17 percent.

Food, industrial products, and seed are important uses of corn, but the amount used for these purposes is small compared with the amount used for feed and exports. Annual use during the past decade has been about 130-140 million bushels for breakfast foods and other food products, about 200-240 million bushels for wet milling products, 25-35 million bushels for alcohol and distilled spirits, and 11-17 million bushels (less than one half of 1 percent) for seed. Most of the seed is produced by specialized seed growers. Corn is by far the leading feed grain in the United States, accounting for from 73 to 79 percent of the total tonnage of the four principal feed grains produced during the past 10 years.

The United States exports corn to all parts of the world. Countries to which the largest volume has been shipped in recent years include Japan, the U.S.S.R., the Netherlands, Italy, West Germany, the United Kingdom, and Spain. Some of the other principal exporting countries are Argentina, France, Republic of South Africa, and Thailand.

RESEARCH NEEDS

The following were identified as the important problems that require research related to corn.

Rank Order		
		Production
1	SP	Increase the genetic diversity in order to lower its vulnerability to pests and diseases.
2	SP	Increase genetic resistance to diseases and pests.
3	SP	Develop improved breeding systems by such means as integrating exotic germplasm and methods of plant population improvement.
5	SP	Develop biological, ecological, mechanical, chemical, and integrated systems of weed control.
7	SP	Breed corn with improved efficiency in using resources such as nitrogen and other soil nutrients, moisture, and sunlight.
7	SP	Determine the most effective and productive cultural practices and the plant types that will give top production under the best conditions.

Rank Order		
		Production (continued)
7		Develop integrated approaches toward efficient corn production that include soil science, pest management, product utilization, and interrelationship among other crops.
10	SP	Develop intergeneric crosses.
11	S	Develop and evaluate tillage systems that use residues or other soil surface treatments to control runoff and erosion.
12		Study methods of identifying cytoplasms and effects of different cytoplasms on the plant.
14	SP	Develop better systems of pest control which minimize pesticide hazards.
17		Accelerate and coordinate research in use of the whole corn plant with particular attention to early maturity, dry ear on green stalk, improved nutrient quality of stalk, mechanization more adapted to medium sized, family labor farm.
18	S	Increase tolerance to cold.
	S	Improve photosynthetic capability and efficiency.
	S	Improve seed vigor, viability, and resistance to deterioration in storage.
	S	Investigate the genetic and physiological processes affecting nutrient uptake and use.
	S	Develop nitrogen fixation capability.
	S	Develop more effective ways to measure and select for yield responses.
		Marketing and Processing
4	SP	Improve handling, drying, and storage techniques to conserve energy and to reduce losses of grain and silage, with special attention to mycotoxins.

Rank Order		
		Marketing and Processing (continued)
6	SP	Investigate alternative approaches to practical and economical grain drying, such as solar heat, low temperature drying, early maturing varieties, and field drying.
12		Develop objective mechanical grain grading and sampling and revise grain standards to be compatible with automatic grading.
14	S	Determine present and future needs for the distribution of corn, corn byproducts, and products produced from corn so that a plan can be developed to meet future needs.
16	S	Evaluate potential reorganization of the transportation system, considering location of grain storage facilities, cost of transportation, and general costs and benefits.
18	S	Develop foreign markets for corn.
		Consumer Needs
20	S	Improve the chemical composition of corn in order to better meet human nutritional requirements, including protein quantity and quality.

4.4 GRAIN SORGHUM

Objective: To develop production, marketing, and utilization practices to assure an adequate supply of sorghum grain and forage for livestock and poultry needs and a grain supply for industrial and food use in the U.S. and in less developed countries, while minimizing loss of resources and environmental quality.

SITUATION

The World

Grain sorghum is likely to play a secondary role in easing world food shortages as income and population growth increase (1) feed demand for higher yielding, higher energy corn in the developed countries and (2) food demand for wheat and rice in the developing ones. Grain sorghum currently accounts for about one-sixteenth (40 million hectares) of the world's total grain area, but only about one-twenty-fifth (47 million tons) of total grain production.

Sorghum yields have increased by about 2 percent per year to a current level of 1.15 metric tons per hectare, or less than two-thirds of the average yield for all grains. Roughly half of the sorghum produced, but more than three-fourths of the sorghum area planted, is concentrated in the grain-deficit developing countries of Asia and Adrica. Yields in these regions have stagnated at roughly 0.65 metric tons per hectare for the past two decades. Much of this stagnation is due to outdated technology and/or or subsistence farming techniques. But a large part of the problem is due to the average farmer's relegation of grain sorghum to marginal dry-land. Increased pressure on wheat, rice, and corn supplies and the development of dry-land farming techniques making it possible to plant higher-yielding grains on the same marginal land have exacerbated the problem.

Little of the sorghum produced in these developing countries enters even national markets. Roughly a fifth is consumed as feed for livestock in a few of the higher income countries. In sharp contrast, the rest is produced and consumed as a food staple in subsistence rural areas.

Sorghum production outside Asia and Africa is concentrated in the United States and Argentina where yields, currently about 3 metric tons per hectare, have been increasing by about 2.5 percent per year over the past 15 years. Even in these grain surplus areas, however, sorghum is generally grown on marginal, dry-land unfit for corn

cultivation. The little sorghum that does reach the international market is traded among the developed countries. Consumption is largely in the form of feed for livestock fattened in the United States and Japan.

Prospects for expanding sorghum production to meet the growing demand for food in the developing countries and feed demand in the developed countries depends largely on the success of research in dry-land farming. Adoption of dry-land farming practices developed by the International Research Institute for the Semi-Arid Tropics and substitution of higher yielding varieties similar to those used in the United States, could triple production in India and the Sahel by 1985. Marked advances in farming techniques and seed hybridization could lead to replacement of sorghum by other higher yielding coarse grains and relegation of sorghum to even more marginal areas. Both USDA and FAO projections have kept the limited potential for expanding sorghum production in mind. Only modest increases in world production and sharp decreases in sorghum's share of both the coarse grain total and the wheat, rice, and coarse grain total have been projected to 1985 and beyond.

The United States

Grain sorghum is the second most important feed grain grown in the United States. In the early 1970's, it accounted for about 12 percent of the total tonnage of the four principal feed grains. Sorghum is also grown for silage or fodder in areas where the growing season is too short or there is not enough moisture for grain production or when late planting, drought, or early frost restrict the development of grain and make utilization for silage or fodder a better alternative.

In years of extensive abandonment of winter wheat in the southern Great Plains, grain sorghums are used to replant about half the abandoned wheat acreage in order to produce some income. In drought periods of 2 or more years, sorghum acreage is usually expanded to produce feed for livestock, and more of the acreage is harvested for fodder or silage than in nondrought years.

The acreage of sorghum planted for all purposes expanded from less than 10 million in 1930 to 27 million in 1957 and since then has been at a level of around 16-20 million acres. Sorghum harvested for grain increased from 3.5 million acres in 1930 to 20 million acres in 1957 and then, after a decline to 11 million acres in 1961, gradually increased to around 13-16 million acres in more recent years.

Expansion of sorghum grain production would have been more rapid except for the restrictions and inducements of Federal farm programs aimed at limiting supplies and supporting prices of feed grains. Total production of sorghum grain during the past 10 years has ranged from 673 million to 930 million bushels. In the 1930's, the range was from 19 million to 72 million bushels.

Average yields of sorghum grain rose from around 14 bushels per acre in the early 1930's to 22 bushels in 1956 (the year preceding introduction of hybrid seed) and continued to increase to a range of 50 to 55 bushels in 1965-69. Increased use of hybrid seed and commercial fertilizer, more effective moisture conservation and weed control, improved tillage, more irrigation, and reduction of harvest losses have all contributed to the strong upward trend in yields. The record average yield of 60.5 bushels per acre in 1972 is a sign that the potential for even higher yields continues strong.

The principal region of sorghum grain production in the United States is the southern Great Plains. In this region, the characteristically short supply of moisture and the extremely high temperatures and hot winds in July and August are very adverse to successful production of corn. Sorghums are better adapted for growth and development under these stress conditions. Since the introduction of hybrid sorghum, with its higher yields (20-30 percent), grain sorghum has been replacing nonirrigated corn acreage in the eastern portion of the southern Great Plains. On the western edge of the Corn Belt, both corn and grain sorghum are produced, but farther to the west and southwest the lower rainfall, higher temperatures, and drying winds tend to make sorghum the more reliable and more productive crop. As water resources become more limited in these areas, making irrigation more costly, sorghum is likely to replace corn to a greater extent.

The leading States in sorghum grain production are Texas, Kansas, and Nebraska. In 1973, these three States accounted for 81 percent of the acreage harvested and 83 percent of the United States production of sorghum grain. Other States with production exceeding 10 million bushels in 1972, 1973,and 1974 are Oklahoma, Missouri, California, Arizona, and South Dakota.

Most of the sorghum grain grown in the United States is used as feed for livestock. During the past 10 years from 75 to 85 percent of the crop has been fed domestically to livestock and 14 to 24 percent has been exported. From 4 million to 11 million bushels annually have been processed into food and industrial products, while 2 million bushels annually have been used for seed. Exports go to many countries in the Eastern and Western Hemispheres. The leading foreign markets for United States sorghums in 1972 and 1973 were Japan, Israel, India, Venezuela, Mexico, and the Netherlands.

RESEARCH NEEDS

The following were identified as the important problems that require research related to grain sorghum.

Rank Order		Production
1	SP	Improve the photosynthetic capability and efficiency of sorghum.
2	SP	Develop alternate sterility systems to reduce vulnerability to biological hazards.
3		Determine the most efficient and productive cultural practices and the plant types that will give top production under dry-land and irrigated conditions.
4		Identify factors affecting protein digestibility.
5	SP	Develop plant resistance to insects such as sorghum greenbug, sorghum midge, and Bank's grass mite.
6	SP	Improve efficiency of water use and drought tolerance.
7	SP	Investigate soil and crop management systems and other techniques such as soil covers and antitranspirants, to increase efficiency of water use.
8	SP	Develop weed control systems.
9	SP	Develop pest management systems.
9	SP	Develop high-yielding hybrids best suited for livestock feeding.
12	SP	Develop alternate sterility systems for producing hybrids.
12	SP	Develop new sorghum types with a broader genetic base.
14	SP	Develop resistance to such diseases as maize dwarf, mosaic virus, and downy mildew.
16	SP	Determine the nature of host-pest interactions and resistance to pests and environmental stress.

Rank Order		
		Production (continued)
18	S	Reduce fertilization requirements; screen types of sorghum to locate differences in nutrient absorption from varying soils.
19	SP	Continue development of high-protein, balanced amino acid types of sorghum.
19	SP	Develop standby breeding stocks to minimize genetic vulnerability.
	S	Collect, evaluate, and maintain sorghum germplasm from throughout the world.
	S	Study aspects of water use related to (1) water loss through evapotranspiration and (2) metabolic efficiency.
	S	Identify variables involved in digestibility of forages.
		Storage and Marketing
11	SP	Develop export markets.
14		Identify insects affecting stored grain and develop methods for their control.
16	SP	Develop more energy-efficient systems of drying grain.

4.5 BARLEY, OATS, AND RYE

Objective: To develop production, marketing, and utilization systems to assure adequate supplies of barley, oats, and other small grains for United States livestock needs, industrial uses, and export demands, while minimizing loss of resources and environmental quality.

SITUATION

The World

Much of the increase in world grain availability over the past 10-15 years is a result of substantial growth in barley production. World barley production has expanded by more than 6 percent per year or roughly twice as fast as total grain production. Area harvested has grown by about 2.2 percent or 1.4-1.5 million hectares per year while yields have increased by 2.9 percent per year to their current peak of 2.9 metric tons per hectare. But these world figures camouflage barley's heavy concentration in the high-income countries. Roughly four-fifths of the world's current 160 million metric tons of barley is produced and consumed in the developed countries, particularly Western Europe and the Soviet Union. Anywhere from one-half to three-quarters of the barley crop is used for feed while much of the rest is used in brewing and distilling.

Yields in the developed countries as a group average 3.2 metric tons per hectare compared with Western Europe's average of 3.3 tons per hectare. Area in the developed countries has grown by more than 3 percent or 1.6-1.8 million hectares compared with an average increase in Western Europe's area of 3.7 percent or 400,000-500,000 hectares per year. However, yields in the developing countries have increased less than 1.6 percent per year while area has actually dropped by 1.5 percent or 200,000-300,000 hectares per year.

Much of this expansion in barley production has been at the expense of oats and rye. World area harvested in oats has declined by about 1.6 percent, or 500,000-600,000 hectares per year, over the past two decades. Oat yields have increased by about 2.5 percent per year from a base of 1.4 metric tons per hectare over the same period. Production of oats has fallen from 60 million tons in 1960 to 51 million tons in 1974.

Rye area, production, and yield have followed similar patterns. World rye area has decreased by 4.4 percent or roughly a million hectares per year over the past two decades. Rye yields have increased by about

3.3 percent per year from a base of 1.3 metric tons per hectare in the same period. Rye production has fallen from 37 million metric tons in 1960 to 29 million metric tons in 1973-74. The largest proportion of both the oat and rye decreases have been concentrated in Europe and the United States.

Barley is likely to continue to play a major role in meeting the expanded world demand for food and feed grain. Growth in feed and beverage use, particularly in Eastern and Western Europe and the Soviet Union, is likely to lead to further expansion of barley area and improved barley yields. While barley is expected to account for a smaller share of total grains fed, it will continue to dominate in developed countries that are unable to produce or unwilling to import large amounts of corn. Food demand for barley is likely to grow less rapidly. Increases in barley production will most likely come from continued growth in barley area, partially at the expense of oats and rye. Yields are expected to continue to grow at or above the trend level of the past two decades.

The outlook for oats and rye is somewhat bleaker. Continued decline in the importance of draft animals--particularly horses--will most likely accelerate the shift from oats to higher yielding more versatile feed barley. Production of oats is likely to continue to be important primarily in relatively cool northern climates or in areas where oats fit into a particular crop and livestock system. Research to improve yields and grain quality could stabilize oat production in the longer term since the grain provides relatively low-cost protein of higher quality than the other major feed grains. Oat improvements have been hampered by disease problems, particularly new races of crown and stem rust that frequently have caused new cultivars to be short lived. Consequently, oat cultivars have not been developed which can be subjected to the high-fertility and intensive management practices used with corn and grain sorghum.

The shift from rye to other food grains is likely to taper off. Regional European rye food demand and wider world industrial demand are expected to keep rye production from slipping much further below current levels. Research that leads to raising wheat yields, however, will ensure the allocation of any increased foodgrain area to wheat rather than rye.

The United States

Barley--The planted acreage of barley fell from 15-16 million acres annually in the late 1950's and early 1960's to 10-11 million acres in the early 1970's. Harvested acreage fell at about the same rate as planted acreage during this period, generally tending to be about 1.0-1.5 million acres less than planted acreage.

Yields of barley per acre harvested rose from slightly less than 30 bushels per acre in the late 1950's to slightly more than 40 bushels per acre in the early 1970's. Total production has tended to rise

only slightly, generally within a range of 390-425 million bushels annually (8.5 million to 9.2 million metric tons).

Domestic use of barley for the production of malt rose during the past two decades from about 90 million bushels annually (about 2 million metric tons) to about 135 million bushels annually (2.9 million metric tons). Most of this is used to produce alcohol and alcoholic beverages, mainly beer. Small amounts of malt are used for food such as breakfast cereals. The quantity exported has been variable, ranging from 17 million bushels to 118 million bushels annually during the past 20 years. Use as livestock feed in the United States generally has been within a range of 200-250 million bushels, or 50 to 60 percent of the annual production.

Barley is produced over much of the United States, but the major areas of production are in the upper plains and the western States. North Dakota is the principal State where barley is produced, and Montana and California also are major producers. Barley competes with wheat for land in the major producing areas. The acreage of barley planted each year thus depends to some extent on acreage control measures taken under price support legislation for wheat.

Oats--Declining acreage has characterized the production of oats since the mid 1950's. The acreage of oats planted for all purposes was 47 million in 1955 compared to 18 million in 1974. The acreage harvested for grain fell from 39 million to 13 million in the same period. Oats have been used widely for grain production, for hay, and as a cover crop. Production is concentrated in the North Central States. Increased competition for land by corn and soybeans has resulted in substantial declines in acreage, particularly throughout the Corn Belt.

Yields per acre harvested of oats have increased during the past two decades, but the increase in yield lags far behind that of corn and grain sorghum, the major feed grains. During the late 1950's, yields have tended to be in the neighborhood of 50 bushels per acre, with a peak of 55.9 bushels per acre in 1971. Part of the reason for smaller production gains may be found in changes in the proportion grown in the various production areas.

The major use of oats in the United States is for livestock feed. In recent years, about 80 percent of the oat production has been used for this purpose. Breakfast cereals account for about 50 million bushels annually, or 5 to 8 percent of production. (Increased awareness of the value of oats for human food should be fostered.) Another 5 to 8 percent of United States oat production is used for seed. The rest is exported.

Rye--Rye is a minor crop in the United States. The acreage seeded annually generally has been between 4 million and 4.5 million acres since 1955, but typically only about a third of the seeded acreage

is harvested for grain. It is widely used as a winter cover crop, for soil protection, and for grazing. Beginning with 1972, the planted acreage fell to a range of 3.2-3.5 million acres, while the proportion harvested for grain fell to less than 30 percent of the acreage seeded.

The yield of rye per harvested acre typically was 2 to 3 bushels lower than that of wheat prior to 1970, but the difference widened during the early 1970's. The yield of rye per harvested acre was about 16 bushels during the late 1950's and increased to about 26 bushels per acre during the early 1970's. Total annual production of rye generally has been in a range of 25-30 million bushels.

Although rye is considered to be a food grain, livestock feed typically accounts for 40 to 50 percent of annual disappearance. The amount ground for flour has shown only minor changes from year to year, generally falling within a range of 5-5.5 million bushels annually. Industrial use, primarily for the production of alcohol, has exhibited greater variability. This use has been declining in importance in recent years, requiring slightly more than 3 million bushels annually during the early 1970's. Seed requirements are in the range of 5-5.5 million bushels annually. Export volumes have been variable, ranging from less than a million bushels to nearly 27 million in the past 20 years.

RESEARCH NEEDS

The following were identified as the important problems that require research related to barley, oats, and rye.

Rank
Order

Production

1 SP Improve lodging resistance in barley and oats.

2 SP Increase tolerance to environmental stresses such as drought, high temperatures, and winter killing.

3 SP Develop broader genetic resistance to pests to avoid losses when resistance to a particular pest race becomes ineffective.

4 SP Develop varieties that perform well with limited moisture.

5 SP Breed winter oat and winter barley varieties with early maturity and increased winter hardiness for double cropping in northern areas.

Rank Order		
		Production (continued)
6	SP	Develop new, genetically diverse, multipest resistant varieties.
7	SP	Improve feed grain quality of barley.
8	SP	Develop oat varieties with improved protein quantity and improved amino acid balance.
8	SP	Increase digestible energy of oats.
10	SP	Develop methods of minimum tillage and no-tillage, and compare them with conventional methods.
11	SP	Develop integrated systems of weed control that reduce energy use.
12	SP	Continue to search for measures to control the cereal leaf beetle.
13	SP	Explore the possibility of developing nitrogen fixing systems.
14	SP	Improve photosynthetic capability and efficiency.
14	SP	Develop more tolerance or resistance to pesticides, particularly herbicides, in order to make more use of selective chemicals.
16	SP	Reshape plants to make better use of sunlight and to increase the ratio of economic to biologic yield.
16	SP	Breed plants that can take more of a particular mineral from the soil and use it more efficiently.
18		Continue research on production and utilization of triticales.
20	SP	Develop double-cropping practices.
		Marketing and Processing
19		Study the effectiveness of barley varieties in brewing.
	S	Increase use of byproducts from barley used in malting and brewing.

5.1 SOYBEANS

Objective: To provide an adequate supply of vegetable protein and oil to meet domestic and world needs and to make optimum use of production and marketing resources.

SITUATION

The World

Soybean oil accounts for about one-fifth of the world production of edible vegetable oil. It is the leading edible oil in the U.S. food fats economy--accounting for more than half of all fats and oils going into food products. It accounts for about 80 percent of the fats and oils used in making margarine, more than 70 percent of the oils used in cooking and salad oils, and about 60 percent of the fats and oils used in the production of shortening.

Soybean meal accounts for about half the world production of oilseed meal and for nearly 90 percent of all high-protein oilseed meal produced in the United States. In terms of amino acid balance, it is one of the best of the vegetable protein family. This valuable high-protein concentrate is used in feeding livestock and poultry. It is particularly suited for feed formulations for poultry, hogs, and other monogastric animals because of the inability of these animals to utilize large quantities of fiber.

Soybeans are important because of their valuable oil and protein content. Many other fats and oils, such as cottonseed oil and lard, are joint or byproducts of other industries, which tend to make their production inelastic. However, soybean production responds readily to changes in price.

The battle to provide an adequate world food supply requires increased availability of protein foods. Because of their high protein content--about 40 percent on a moisture-free basis--soybeans have a decided advantage over other oilseeds.

Edible soy protein is important in the diet of peoples of the Far East. Currently, there is much interest in this and other countries of the Western world in the manufacture of edible protein, such as meat extenders or meat analogs. Although practical problems exist, this is an area of vast potential. Any significant breakthrough could profoundly affect the food industry of this country and of the world. Some important considerations are the degree of shift from an animal-based to a vegetable-based protein diet and the effects of

an increased protein supply available to a protein-hungry world. Other considerations include the possibility of less use of soybean meal in animal feeds.

World soybean production is concentrated in three countries--Brazil, Mainland China, and the United States. These three countries normally account for 90 percent or more of world soybean production.

Production has trended steadily upward for the past 25 years. Most of the increase has come from the United States, although, in recent years, Brazilian production has expanded significantly. During 1960-73 U.S. production rose from 15.1 million to 42.9 million tons, production in Brazil rose from 0.25 million to 7.5 million tons, and that of Mainland China rose from 8.2 million to 6.7 million tons. Recently, higher price levels have stimulated efforts to expand soybean production in France, Italy, Mexico, Argentina, Uruguay, Nigeria, Thailand, and other countries. So far those efforts have met only moderate success.

Unlike some cereal grains, area trends for soybeans are very closely related to production trends. In the United States, soybean area expanded from 10 million hectares planted in 1960, to 23.2 million hectares planted for the 1973 crop. In the same period, Brazilian area expanded from 0.2 million hectares to 4.2 million hectares and area in Mainland China contracted from 9.3 million to 8 million hectares. Within the United States, much of the change in area was due to year-to-year modifications in feed grain and cotton programs. In Brazil, the soybean buildup started by double cropping soybeans with wheat. However, in the past 2 or 3 years, most of the expansion has come from development of new farmland as Brazilian agriculture has pushed farther west. In China, soybeans have tended to be replaced by cereals.

Soybean yields have not risen dramatically during the past 2 decades. In the United States, yields per harvested hectare were reported at 1.46 tons in 1950, 1.62 tons in 1960, and 1.79 tons in 1970. A record 1.87 tons was reported in 1973. Both Brazil and the Peoples Republic of China reported 1970 yields that were about the same as those reported in 1960. However, in Brazil reported yields since 1970 have risen rapidly and nearly equal those of the United States.

If soybean production continues to be relatively profitable in the United States and Brazil, it is likely that U.S. production will be in the 55-60-million-ton range by 1985 and Brazilian production will be about 10 million tons. Production in China is not expected to show much change during the next 10 years.

The United States

Originally, soybean production was concentrated mainly in the Midwest Corn Belt. Over the past 50 years, it has expanded into the Delta and Southeastern States. Planted acreage expanded from less than 5 million acres in 1925 to 57 million in 1973. Production rose from about 5 million bushels in the earlier period to a record 1.5 billion bushels in 1973. The increase was due mainly to expanding acreage, as yields per acre rose at a much smaller rate. Yields rose from about 11 bushels per harvested acre to nearly 28 bushels in 1972 and 1973.

Some important factors that influenced the expansion in acreage were: Introduction of high-yielding hybrid corn released new surplus corn acreage. Farm mechanization released oat and hay acreages that formerly were required for feeding farm animals. Crop acreage controls on crops such as corn. A shift in consumer demand toward end products that require more vegetable oils and oil meals. Technological changes reduced costs in the production, processing, and transportation of soybeans.*

When processed, a bushel of soybeans yields about 47½ pounds of meal and about 11 pounds of oil, or a ratio of nearly 4.5 to 1. Soybean meal averages around 45 percent protein. Based on price per pound, the oil is more valuable than the meal. In recent years, the meal has accounted for about 60 percent of total product value, the oil about 40 percent.

Soybeans vary in oil and protein content from region to region and even from farm to farm. Generally, soybeans that have a high percentage of protein have a low percentage of oil, and vice versa.

Oil content of soybeans shows a tendency to increase from north to south while meal tends to decrease. While oil content is highest for soybeans grown in the South, the North Central States have higher seed yield and consequently higher oil yield per acre.

If world supplies of vegetable oils and protein are to be kept abreast of an increasing population demanding a more nutritious diet, and if the United States is to maintain or increase its share of world trade in these commodities, top priority must be assigned to soybean research.

*Blagwant, Singh, and Clifford C. Taylor. The Competitive Position of Maryland Soybeans. University of Maryland Bulletin No. 473, University of Maryland, College Park, Md., Agricultural Experiment Station. June 1962, p. 5.

Roughly half of our soybean production is exported in the form of beans, oil, and meal. The export market is now the fastest growing outlet and probably will continue so in the immediate future. Soybean exports for 1974-75 are estimated at 900 million to 1,000 million pounds.

Soybeans and products are one of our major agricultural exports and play an important role in our balance of trade. The oil finds immediate acceptance in margarines and shortenings, but its market in salad and cooking oils is less secure.

Future expansion of soybean acreage may prove more difficult to achieve than in the past. Now soybeans must compete for the available land with corn, cotton, and other crops. The ability to increase future production will hinge heavily on varieties adapted to new or a wider growing range and increasing yields per acre.

There are no hybrid soybeans, and chances for a breakthrough appear slim. Increasing yield per acre probably will continue as a slow, gradual process, resulting from technological advances in disease and insect resistance and in obtaining more adaptable varieties. Encouraging farmers to develop more efficient cultural practices such as better control of weeds, insects, and diseases, along with better use of fertilizer, also should help increase yields.

RESEARCH NEEDS

The following were identified as the important problems that require research related to soybeans.

Rank Order		
		Production
1	SP	Develop systems and practices to maximize yields and minimize inputs.
3	SP	Develop high-yielding varieties for different production and pest conditions, including root and stem rot diseases and photoperiod insensitivity.
4	SP	Determine the factors that offer substantial promise in breaking yield barriers.
5		Expand and accelerate conventional and innovative breeding programs.
7	SP	Increase knowledge of soybean genetics through cell genetics and other cell studies.

Rank
Order

Production (continued)

Rank Order		
8	SP	Broaden the germplasm base by exploration, exchange, and broadened use of existing collection.
9	SP	Study nitrogen metabolism, including fixation systems.
9	SP	Identify the plant characteristics that limit seed yield and production of oil and/or protein under different crop conditions.
12	SP	Identify more effective strains of rhizobia and develop techniques for inoculating the soil with them.
12	SP	Develop technology to maximize seedling vigor and viability and to reduce seed deterioration in storage.
15		Establish a system of international nursery and variety testing.
18	SP	Increase understanding of soybean nutrition and related rooting patterns.
19	SP	Study the physiology of reproduction, including the hormones that control distribution of materials between vegetative and reproductive sites.
	S	Determine the best combinations of tillage and harvesting operations for single and double-crop systems.
	S	Evaluate soybean harvesting systems and equipment to reduce field and handling losses.
	S	Develop herbicides and application methods for hard-to-control weeds.

Marketing and Processing

Rank Order		
6	S	Develop export market opportunities including trade barriers and tariffs.
15	S	Develop faster transfer systems that are more economical, speed up loading operations, and reduce grain damage.

Rank Order		Consumer Needs
2		Develop workable guidelines to determine the significance to human health of minute residues of chemical substances in all food production.
9	S	Develop means of eliminating the "beany" flavor, flatus factors, and color of full fat and defatted soy flour.
12	SP	Develop varieties with little or no flatulence factors or trypsin inhibitors.
15	SP	Increase acceptability and overcome impediments of soy products as human food.
19		Improve utilization and development of new consumer products and nonfood uses.

5.2 COTTONSEED

Objective: To provide an adequate supply of cottonseed protein and oil to meet domestic and world needs with minimal adverse environmental impact.

SITUATION

Cottonseed is processed to yield oil and meal. Cottonseed oil accounts for about 10 percent of world production of edible vegetable oil. In the United States, it is the second most available edible vegetable oil. U.S. production was 6.1 million tons in 1962 but was only 5.4 million tons in 1972. Cottonseed oil is used widely in the United States in the manufacture of margarine, shortening, and cooking and salad oils.

Since cottonseed is a byproduct of cotton, supplies depend on cotton production. Future supplies of cottonseed will depend on the outcome of the competition between cotton and synthetic fibers. The recent rise in the cost of petroleum--the major base for synthetic fibers--may change world fiber use. In 1974, the cotton-synthetic fiber use ratio increased in favor of cotton for the first time in the past decade. World cotton production has risen, particularly in areas where food supplies are critical. Hence, the cotton grown in these areas would be of use for both fiber and food.

Cottonseed meal is a largely untapped source of protein for humans. Most of it now goes into livestock feeds because of its toxic yellow pigment--gossypol. World production is about 24 million tons of seeds. In many countries, the seeds are not used effectively even as livestock feed and are not used at all for human food. Over the past 35 years, cottonseed yield has more than doubled to its present average of about 800 pounds per acre.

Gossypol is a problem in both the oil and the meal. The liquid-cyclone process removes gossypol from the seeds, and makes it possible to produce flour and several other edible products. The first large-scale plant using the liquid-cyclone principle has been built at Lubbock, Texas. This plant expects to go into commercial production of cottonseed flour.

Gossypol-free varieties have been developed and are used to a limited extent in the United States, but they must be improved. They are susceptible to pests. Also, these varieties must be adapted not only to the United States but to other cotton production areas of the world. Even with the liquid-cyclone process, glandless cottonseeds

are desirable. With glandless seed, the recovery of protein for human food is much higher than for glanded seed because much protein is lost with the gossypol-contaminated "underflow" in the liquid-cyclone process.

Other current developments in the cotton industry have a bearing on the future for cottonseed. These are: Improved technology in spinning yarn and weaving fabrics reduces the need of giving priorities to fiber attributes in developing cultivars, hence, emphasis can be given to yield of seed and fiber. The value of glanded and glandless cottonseed has increased in value to within one-fourth and one-third respectively of the value of lint per acre. In cultivar development, the ratio of lint to seed can be reduced to permit production of more seed per acre without appreciable reduction in lint yield per acre. Emphasis is being given to host resistance (diseases and insects) in developing cultivars. New management practices developed under the short-season concept make it possible to reduce the cost of producing cotton.

RESEARCH NEEDS

The following were identified as the important problems that require research related to cottonseed.

Rank Order		
		Production
1		Develop high yielding, glandless varieties with multiple pest resistance.
3	SP	Develop improved pest management systems and production practices that use the optimum combination of chemical and biological inputs.
3		Develop cotton varieties with resistance to mycotoxin-producing organisms.
5	SP	Develop superior varieties, stressing pest resistance, adaptability, extreme early maturity, and natural defoliation.
6	SP	Improve natural and chemical ways to defoliate cotton, including better timing.
9	SP	Identify germplasm with disease- and pest-resistance factors.

Rank Order		
		Production (continued)
10		Improve cultural and pesticide and fertilizer application practices in order to avoid salt and pesticide accumulation in soils.
11	SP	Study desirable oil and protein characteristics and incorporate them into breeding stock and commercial varieties.
12	SP	Determine inheritance patterns of pest resistance.
12		Improve cottonseed and cottonseed products for use in livestock feeding.
	S	Look for useful genetic variations in total protein, amino acid content, and oils.
		Marketing and Processing
6	SP	Improve the liquid-cyclone process for removing gossypol.
8	SP	Improve monitoring for possible mycotoxin contamination.
14	SP	Investigate cottonseed protein extracts and ways of using them in food products.
15	SP	Develop alternate methods of removing glands from meal.
17	S	Determine the most desirable physical characteristics of cottonseed for processing and yield of food products.
17	SP	Determine the most efficient uses of cottonseed protein and oil in food products.
19	SP	Evaluate the potential of cottonseed products in world markets.
	S	Develop improved methods for separating protein into its components.
		Consumer Needs and the Environment
1	SP	Develop workable guidelines to determine the significance to human health of minute residues of chemical substances in all food products.

Rank
Order

Consumer Needs and the Environment (continued)

Rank Order		
16	SP	Study the effect of natural cottonseed constituents on human growth and development.
20		Determine the least-cost method of producing cottonseed products with good flavor and functional properties for an end use.
	S	Develop production systems that use the optimum combination of chemical and biological inputs.

5.3 PEANUTS

Objective: To provide an adequate and nutritious supply of peanut protein and oil to meet domestic and world needs with minimal adverse environmental impact.

SITUATION

The World

Peanuts rank near the top of the world's major sources of vegetable oil. They often displace sunflowers for second place in total oil production. First place is held by soybeans. Peanuts are also very important in international trade, ranking second or third, but behind coconut oil. Even though production is dispersed throughout the world, total peanut production and trade are subject to wide fluctuations due to weather variations.

India, Mainland China, the United States, and Nigeria are the four largest producers. Other important producers include Brazil, Argentina, Senegal, Sudan, Zaire, Niger, South Africa, Burma, Indonesia, and Thailand.

Production trends in the four leading countries are generally upward. In India, 1960 production was reported at 4.5 million tons, and by 1973, that had risen to just over 6 million tons. The generally unfavorable weather of 1974 cut that year's crop back to near the 1960 level. Information on production in Mainland China is very limited; however, indications are that present production is just over 2.5 million tons and is increasing slowly. Nigerian commercial production is estimated to have increased from 0.8 million tons in 1960 to 1.4 million tons in 1970, but reported production varies considerably with the weather and only commercial production is normally reported. No attempt is made to estimate production for subsistence consumption.

Trends in area for the major producing countries, with the exception of the United States, have been mixed over the past 14 years: The Indian area expanded from 6.2 million to 7.3 million hectares. It is estimated that the area in Mainland China expanded from 1.8 million to more than 2 million hectares. The area of commercial peanuts in Nigeria is reported to have remained constant at 1.8 million hectares. In the United States, the peanut area is set by allotment and has changed little from the 1960 level of 0.6 million hectares.

Outside the United States, peanut yields are very sensitive to weather. Although peanut yields in India rose from 0.7 metric tons per hectare in 1960 to 0.8 metric tons per hectare in 1970, yield fluctuations were such that it is not possible to conclude that average yields are rising. Chinese yields appear to have increased slightly. In Nigeria, the reported 1970 yield is lower than that of 1960, probably due to unfavorable weather that started in 1970. In contrast to the other countries, peanut yields in the United States have trended sharply upward. In 1960, yields averaged 1.4 tons per hectare; by 1974, the comparable average wss about 2.8 tons per hectare.

Trends in production have different underlying factors in different regions. In India and China, competition for land has held down potential increases in peanut area. In Nigeria, the very low prices maintained by the Peanut Marketing Board have tended to limit production. In the United States, peanut acreage is regulated by law; however, higher yielding varieties coupled with better management techniques have resulted in rapidly increasing average yields.

The United States

Peanuts are of basic economic importance to many farmers in the Virginia-Carolina area and in parts of the Southeast and Southwest. In all producing areas, peanuts provide substantially greater net returns than the next most profitable crop.

Four commercial types of peanuts are grown in the United States. They are Virginia, Runner, Spanish, and Valencia types, each of which has tended to be grown in different production areas. The new Florunner variety with its very high yields is changing these production patterns. All the major producing areas have contributed to the rise in U.S. peanut production.

Peanuts, a price-supported commodity, are grown under Federal acreage controls and marketing quotas. Since 1956, the annual U.S. allotment has been at the 1.6-million-acre minimum. Planted acreage has held steady at about 1.5 million and acreage harvested for nuts at 1.4-1.5 million. In the absence of acreage controls and with proper economic incentives, acreage and production could be expanded dramatically. However, expansion of acreage outside the present production areas would require development of expertise in handling and shelling technology, storage facilities, marketing structures, and agricultural research and extension work.

While acreage has changed little over the past two decades, production has risen from about 1.5 billion pounds in 1955 to about 3.7 billion in 1974. The uptrend in output is expected to continue as yields per acre continue to increase.

Acreage allotments and rising mandatory support prices, in addition to better pesticides and better management, have influenced the rapid rate of technological advance in production. With land restricted by allotments for peanut production, growers have substituted other inputs such as fertilizer, herbicides, and pesticides for land. They have also shifted to higher yielding varieties, growth of more plants per acre, irrigation, and increased use of mechanical harvesters and dryers. The increase in the average size of farms--made possible by combining allotments within counties--has also helped to boost peanut yields. The average yield per acre harvested for nuts rose from 928 pounds in 1955 to about 2,500 pounds in 1974.

Despite increasing demand for edible peanuts, U.S. production from the statutory minimum allotment has resulted in supplies sharply above the commercial demand. Consequently, prices received by peanut growers have averaged near the price support levels and the Commodity Credit Corporation yearly acquires the surplus peanuts under the price support program. These peanuts are diverted from the edible market into crushing channels and into export markets. In most years, these peanuts were sold at a price considerably below the price the Government paid for them. However, in 1974, the USDA announced that the minimum sales policy for 1974 crop peanuts for diversion sales would be 100 percent of the loan level.

About two-thirds of the total disappearance of peanuts is used for edible products (chiefly peanut butter, candy, salting, and roasting in shell) and related uses. The remaining one-third is crushed for oil and meal, exported, used for seed and feed, or lost on the farm.

The future domestic demand for edible peanuts will depend on such factors as population growth; peanut prices; and the peanut industry's product development, product quality, and merchandizing and promotional programs. Aggregate consumption probably will continue to gain in the foreseeable future, but the annual rate of gain may not keep pace with the 3 percent gain of the past. Significant future gains in domestic consumption of edible peanuts may become more difficult to achieve with higher market prices for peanuts and increased competition from other products--especially in the growing snack-food market. To share in this market growth, peanuts must be competitively priced, and the peanut industry must continue to compete in new-product development and promotion.

Peanut oil is used primarily as a cooking and salad oil. Because of its excellent quality and high smoke point, it usually commands a premium price over some other vegetable oils. Peanut meal, a joint product with the oil of the peanut-crushing industry, is used as a high-protein ingredient in livestock feeds.

RESEARCH NEEDS

The following were identified as the important problems that require research related to peanuts.

Rank Order		Production
1	SP	Develop varieties with higher yield potential, improved nutritional value, improved flavor and flavor stability, better handling and processing quality, and resistance to diseases and insects.
2	SP	Determine environmental factors and production practices that affect seed viability and germination and seedling vigor.
5	SP	Identify and evaluate genetic material that carries resistance to diseases and pests.
6	SP	Develop ways to prevent mycotoxins from forming before and immediately after digging.
9	SP	Determine the plant reactions that control peanut growth, flowering, and fruiting and their interaction with the environment.
10	SP	Develop systems to control diseases and pests, including biological control.
12	SP	Develop field and laboratory techniques for assessing pest and disease resistance.
12		Conduct research in the fundamental biology of the isolated cell as related to antagonistic, symbiotic, and specific reaction of nuclei and cytoplasms as related to expanding use of genetic resources.
12		Evaluate and study the combined disease-nematicide and menaticide-insecticide control management systems.
16	SP	Develop production systems to achieve maximum yield at minimum cost and least loss of soil and water.
16		Conduct research to develop to the maximum the soil environment for peanut production with emphasis on the importance of micronutrients as they affect performance of the plant.

Rank Order		
		Production (continued)
	S	Determine the potential impact of alternative Federal policies on the industry, producer income, consumers, location and level of production, and program costs.
	S	Collect, evaluate, and maintain sources of genetic variability from cultivated and wild species.
	S	Develop production and harvesting systems that will combine most energy efficiency with least environmental impact.
		Marketing and Processing
4	SP	Develop ways to prevent contamination by molds.
7	SP	Determine realistic and safe levels of mycotoxin in peanuts used for animal food.
8	SP	Design better storage facilities and transportation to minimize mycotoxin contamination.
11	SP	Develop new peanut products such as flour, meals, grits, protein concentrates, and isolates, etc.
12	SP	Develop practical ways to detoxify peanuts and peanut products contaminated with mycotoxins.
18	S	Develop economical uses for peanut hulls, skins, wheys, and other byproducts.
19		Identify the causes of undesirable changes in flavor or flavor precursors in peanuts resulting from damage during handling and/or by physiological changes in peanuts during curing, storage, and blanching prior to roasting or processing; recommend solutions to the problem.
	S	Improve equipment for curing peanuts, including use of alternate energy sources.
	S	Develop new systems to evaluate grade and quality of peanuts.
	S	Establish the feasibility of substituting peanuts for other sources of protein in domestic and foreign markets.

Rank Order	Consumer Needs
3	Develop workable guidelines to determine the significance to human health of minute residues of chemical substances in all food products.
19	Develop economical uses for the nutrients contained in the peanut and the peanut plant to meet U.S. and world food demands in production forms acceptable to the eating habits of the people consuming them.

Objective: To provide an adequate supply of protein and vegetable oil from oilseeds such as sunflower and safflower to meet expanding domestic and world needs, with minimum adverse environmental impact.

SITUATION

The World

In addition to soybeans and peanuts, several other crops contribute significantly to the world supply of vegetable oils and high-protein meals:

- First are the traditional annual oilseed crops including sunflower, safflower, rapeseed, and sesame. Although it is in this category, flaxseed is considered an inedible oil in most parts of the world.

- Second, many vegetable oils are obtained from perennial trees. These include olive, palm, palm kernel, and coconut.

- Third, some vegetable oils are produced almost entirely as a byproduct of processing for another purpose. Cottonseed oil and corn oil are the main examples.

A brief discussion of each of the major oil crops in categories one and two follows. There is little purpose in discussing the third category since production is almost totally a function of the supply-demand relationships for the primary products.

Sunflower--Sunflower seed is the world's second most important source of edible vegetable oil. Although the plant is native to the United States, sunflower production is centered in the Soviet Union and Eastern Europe. Argentina is the largest producer in the Western Hemisphere. World production rose from just over 6.1 million tons in 1960 to 8.8 million tons in 1972. Further increases have occurred in 1973 and 1974 as sunflower acreage expanded in the developing countries. Average yields have risen by about 20 percent during the past 10 years. This rise is attributed to the development of higher yielding high-oil varieties by Soviet scientists and to adoption of better management practices. The Soviet varieties have found wide acceptance in many parts of the world.

For meeting world oilseed needs, sunflowers must rank at or near the top of any priority list for research attention. Unlike most crops, sunflowers are blessed with a tremendous amoutn of unexplored genetic variability, thus allowing sunflower breeders to tailor-make varieties for particular climatic zones and environments. Since sunflowers are a relatively new crop, the genetic potentials for yield and other characteristics have only been lightly tapped. Future world production will expand as newer, higher yielding varieties develop and the crop is adapted to other areas of the world.

Safflower--The production of safflower, one of the oldest cultivated plants, has increased in recent years. However, it remains a minor source of edible oil in the world, ranking about equal to corn oil. Safflower, unlike sunflowers, is not widely adapted and can be grown successfully only in a limited geographic area. Historically, it has been grown near the Mediterranean Sea and in India.

Rapeseed--This is the major oilseed grown in Europe, and European policy usually acts to stimulate even greater production. At the world level, India, followed by Canada, is the leading producer. During 1960-72, total rapeseed area expanded from 7.3 million to 10.2 million hectares, and average yields rose from 0.5 to 0.7 tons per hectare. During the late 1960's, it was thought that rapeseed might become the second leading crop in Canada; however, present area there is considerably below the 1971 peak of 2.1 million hectares. Improved wheat prices probably have provided much of the impetus for the decline.

As a product, rapeseed is plagued by two problems--erucic acid in the oil and thioglucosides in the meal. However, there are new varieties low in both of these undesirable substances, and it appears that efforts to develop a variety free of them will be successful. This development will tend to expand the demand for rapeseed.

Sesame--Sesame seed produces a vegetable oil that normally commands a premium price. However, world production is generally confined to areas where labor is cheap since harvesting is still done manually. Ethiopia, India, and Sudan are the three major producers.

Olive Oil--Olives are produced mainly in countries that border the Mediterranean Sea. Production outside that general area is extremely limited. Italy and Spain, the leading producers, account for roughly half of world production, which appears to be trending upward by between 1 and 2 percent per year.

Palm Oil--The oil palm tree is a native of Africa and is found along most of the western coast of Africa. However, aggressive planting programs during the 1960's have made Malaysia the largest producer. Nigeria and Indonesia rank second and third respectively. In addition

to devoting more area to palm oil production, Malaysia has been the leader in adopting the high-yielding Tenera-cross varieties.

World production of palm oil was about 1.1 million tons in 1960; in 1972 the comparable figure was 2.4 million tons. Production in the Federation of Malaysia rose from less than 100,000 tons to more than 700,000 tons during the 1960-72 period. Indonesia also had a significant increase in total production.

Palm Kernel Oil--Palm kernels are a byproduct of the palm oil industry. However, palm kernel production has not risen in the same proportion as palm oil because the new varieties yield a much smaller fraction of palm kernels. Thus, though world production was reported at 1 million tons in 1960, by 1972 it had risen to only 1.3 million tons. Nigeria is the leading producer of palm kernels.

Copra--Production of copra, the parent material for coconut oil, is centered in the Philippines. Second place is held by Indonesia. Total copra production was reported at 3.3 million tons in 1960 and at 4.4 million tons in 1972. During the same period, Philippine production rose from 1.3 million tons to 2.2 million tons. Reported production in Indonesia changed little over the period.

Projections--Projections made prior to the recent worldwide downturn in income growth indicated that annual growth in total vegetable oil production and total demands will be 3.5 to 4.5 percent. In respect to individual commodities, projections conclude that soybean, sunflower, and palm oil will provide the major share of the vegetable oils needed to meet these demands through the early 1980's.

Similar projections for oilseed meals conclude that world production may reach 100 million tons in 1985, nearly double the 1970 base level. Soybean meal is expected to account for the largest share of the increase.

The United States

Sunflower--Oil-type sunflowers were first grown commercially in the United States in 1967, when high-oil Russian varieties were introduced. Prior to this, sunflowers were not an economical oilseed crop in the United States. Since 1967, U.S. production has expanded rapidly with more than 600,000 acres planted in recent years to confectionery and oil-type sunflowers.

Sunflowers yield more than twice as much oil as soybeans--42 percent compared with 18 percent. Newer varieties possess oil content of nearly 3 times as much. Thus, sunflowers must be considered the

premier oilseed crop in the world. When oil prices are strong, sunflower returns more per acre than soybeans. When protein prices are strong, soybeans are a better cash crop. The U.S. average yield of soybeans per acre is about 1,650 pounds compared to about 1,100 pounds for sunflowers. However, sunflowers are adapted to the drier areas of the United States where soybeans perform rather poorly. The superiority of sunflowers over soybeans as an oilseed crop will increase dramatically in the next few years as hybrid sunflowers with substantially higher yields are grown. Sunflowers are widely adapted and can be grown throughout the United States. They are particularly well adapted to the Great Plains area, where other crops frequently suffer from drought. Some varieties of sunflowers have a short growing season and thus lend themselves to double cropping in sections of the United States where the growing season is sufficiently long.

The discovery of an economical system for producing superior F_1 hybrid sunflower varieties has established sunflower as a major U.S. oilseed crop for the future. Hybrid sunflowers are in their infancy. A number of U.S. hybrids will be available for commercial production for the first time in 1975. They will give significantly better performance than open-pollinated varieties. Future increases in yields are anticipated with further technological advances in hybrid development. The incorporation of known disease and insect resistance into agronomic varieties by hybridization will help increase yields, expand the area of production, and stabilize production in other areas. As sunflower production stabilizes and growers become familiar with the management practices, losses from weeds, diseases, insects, and birds will be reduced and yields will be further increased. Implementation of recommended management practices must be encouraged to maximize performance.

Sunflower oil is highly regarded as a salad oil and gives excellent performance as a cooking oil and shortening. Sunflower oil is used to manufacture premium-grade margarines which take advantage of its high ratio of polyunsaturated to saturated fatty acids. Sunflower oil is considered a premium oil on the world market and is widely preferred over soybean oil in many countries. Consequently, most of the United States oil-type sunflowers have been exported instead of processed for consumption by the American public.

Sunflower is unusual in that the fatty acids that make up the oil vary depending upon the temperature during seed development. In northern locations the oil is high in polyunsaturated fatty acids, which is desirable for use in premium margarine, mayonnaise, and salad oil. Sunflowers grown in the south under higher temperatures produce oil which is much more monounsaturated. This oil has a high degree of stability, thus making it a very desirable shortening or cooking oil,

without many of the undesirable characteristics associated with soybean oil. Evidence suggests that this unique property may be under genetic control, thus breeding work should be carried out to develop types which produce specific types of oil. Marketing procedures should be developed to keep the different types separate. With the wide range of different seed colors, it should be possible to use seed color to identify varieties with different ypes of oil.

Sunflower meal, like safflower meal, is one of the few oilseed meals that do not contain toxins. This favors it for use as a high-protein food. A major drawback in using the meal as a human food is a color change in pH level from acid to alkaline. Methods need to be developed to overcome this problem and make sunflower protein more attractive to the food industry. One effort should be to develop varieties free of chlorogenic acid.

There is little doubt that the knowledge, technology, and genetic variability is available to develop sunflower into a premier oilseed crop in many areas of the United States, thus providing the American consumer with an ample supply of a superior premium vegetable oil.

Safflower--U.S. production of safflower is on 150,000 acres and is concentrated primarily on irrigated land in the dry climates of California and Arizona. In this production area, competition with high value crops for the arable land is strong, and safflower acreage appears to be declining. It has also been grown in the western part of the northern Great Plains. The food demand for this oil results from its ratio of polyunsaturated to saturated fatty acids, which is higher than in any other edible oil. Since safflower oil must be priced higher than soybean oil to retain acreage, its future food use may depend somewhat on the result of medical research into causes and remedies for coronary heart disease and the acceptance by the public of safflower oil as a health product. Its closest competitor in this respect is sunflower oil. Whether safflower oil can survive the market competition of increased U.S. production of sunflower oil from hybrid sunflowers remains to be seen.

The oil yield from safflowers is about double that from soybeans--40 percent oil compared to 18 percent. Safflower is usually grown under irrigation or after an irrigated crop in the United States and yields about 2,000 pounds of seed per acre compared to 1,650 pounds of soybeans. Therefore, safflower's yield of oil per acre is considerably more than double that of soybeans. However, safflower competes more with higher value crops for acreage than does soybeans.

Development of hybrid safflower will increase yields and make it more attractive to farmers to grow. Some breakthroughs are required before hybrid varieties are economically possible. Significant increases in

yields of safflower will result from the development of hybrid varieties. Breeding for greater disease and insect resistance should help increase yields and extend its growing areas. Developing cultural practices which will increase control of weeds, insects, and diseases, and better use of fertilization and irrigation should increase the competitiveness of safflower with other crops.

Safflower is unusual in that the fatty acids that make up the oil vary in quantity, so that a high oleic (monounsaturated) type is in commercial production in addition to the high linoleic (polyunsaturated) type. Breeding work should be continued to maximize the amount of certain fatty acids (such as oleic acid) in the seed, thus producing special oils for highly specific uses.

About 100 million pounds of safflower oil goes for edible purposes in the United States annually. Safflower is a premium oil which is used in making very high polyunsaturated margarine, mayonnaise, and salad oils.

Safflower meal is one of the few oilseed meals that do not contain toxins. This favors its use as an edible protein. However, at present, all safflower meal is used in livestock and poultry feeds. One of its disadvantages is its low-protein content of 20 percent; however, the hull can be removed to yield a 42-percent protein meal. The hull is high in silica which is undigestible and also contains too much fiber for use in human foods. Therefore, hulls must be removed from the meal before it goes into edible uses. Development of better methods of hull removal or breeding to make the hull easier to remove would be beneficial.

RESEARCH NEEDS

The following were identified as the important problems that require research related to sunflower, safflower, and other oilseeds.

Rank
<u>Order</u>

<u>Production</u>

1 SP Develop hybrid sunflower varieties adapted to specific production areas.

3 SP Improve insect and disease control in domestic sunflower varieties.

4 SP Develop management systems to make most effective use of available moisture, nutrients, and growing seasons.

Rank Order		
		<u>Production</u> (continued)
5	SP	Reduce the genetic vulnerability to pests of safflowers, sunflowers, rapeseed, and flax.
8	SP	Develop more understanding of the genetics of oilseed crops.
9	SP	Develop high-yielding, more widely adapted varieties of sunflower, safflower, and flax.
10	SP	Develop production practices to optimize yields with minimum tillage and purchased inputs.
11	SP	Breed more photosynthetic efficiency into sunflowers, safflowers, and flax.
13	SP	Determine the genetic variability of nutrient factors in oil-protein crops.
15	SP	Determine the condition and cropping situations under which specific oil-protein crops have a comparative advantage.
20	SP	Develop high-yielding safflowers with resistance to <u>Fusarium</u> wilt, <u>Verticillium</u> wilt, <u>Phytopthora</u> root rot, and rust.
	S	Develop high-yielding, rust-resistant varieties of flax.
	S	Develop multicropping systems to make better use of available land, moisture, and plant nutrients for higher yields.
	S	Develop flax germplasm with greater variability than now available through hybridization.
		<u>Marketing and Processing</u>
12		Develop efficient dehulling methods.
15	SP	Evaluate the impact on the U.S. oilseed market of changing world production patterns.
18	SP	Improve flavor and odor stability of salad and cooking oils and raise their polyunsaturated content.

Rank Order		
		Marketing and Processing (continued)
19	SP	Evaluate the potential for plant protein products in both U.S. and foreign markets.
		Consumer Needs
1		Develop workable guidelines to determine the significance to human health of minute residues of chemical substances in all food products.
6	SP	Eliminate or minimize hazards of mycotoxins and pesticide residues in oilseeds and their products.
7		Develop varieties and processing technology to lower the chlorogenic acid content with greater consumer acceptance for sunflower products.
14		Investigate the desirability of blending oils from different oilseed crops to improve quality and usability.
15	SP	Determine consumer acceptance of new foods or products developed from plant oils and protein.
	S	Develop sunflower varieties with desired combinations of fatty acids.

5.5 SUGAR

Objective: To assure an adequate, stable supply of domestic and foreign sugar to meet U.S. and world needs, with desirable socioeconomic and environmental impacts.

SITUATION

The World

The world sugar situation is tight and is likely to remain so for the next few years. Even if production exceeds consumption for the 1975-76 crop year, carryover stocks may not be rebuilt to the desired level of 25 percent of world consumption. World production and consumption are expected to increase for several years to come. The United Nations estimates that the world will need 107 million metric tons of sugar in 1985.

World sugar production for the 1974-75 crop year is estimated by the USDA at 79.7 million metric tons, raw value. World consumption is estimated at the slightly higher figure of 80 million tons. However, in 4 of the past 5 years consumption has exceeded production and carryover stocks fell to the low level of about 16 million tons at the beginning of the 1974-75 season. World beet sugar production for 1974-75 is estimated at 30.2 million tons, while cane sugar production will account for 49.5 million tons, or 62 percent. The 1974-75 crop fell short of expectations due primarily to poor weather in much of Western Europe and the U.S.S.R.

Sugar prices hit their all-time record high on November 20, 1974, when the New York duty paid price was at 64.50 cents per pound and the world price was 65.50 cents on an f.o.b. Caribbean Port basis. The price run-up in 1974 was probably caused by a number of factors, including (1) the energy crisis, (2) inflation, (3) uncertainties in regard to expiration of the U.S. Sugar Act, (4) poor crops in Europe, and (5) the fact that low world prices had discouraged needed expansion of sugar production. The energy crisis had a double-barreled effect, as it caused costs to rise and it put dollars into the hands of Middle East countries which bought very aggressively. The snowballing effect of these factors on prices should have abated, and 1975 prices should be much more stable.

The recent high prices have not resulted in a real rush to build new sugar mills. This is because of the high cost of constructing mills and the memory of depressed world prices following the shortage of a decade ago. However, new mills are planned for the Philippines,

Panama, Nigeria, Tanzania, Ivory Coast, El Salvador, Indonesia, Morocco, Portugal, Honduras, and Mexico, as well as for some other countries. Production is expected to rise in these countries, and milling capacity will be expected to accommodate it.

The United States

The United States which now produces about 55 percent of its consumption requirements, is the world's largest importer of sugar. In 1974, imports amounted to about 5.8 million short tons (5.26 million metric tons) raw value. Import requirements in 1975 will be considerably less since U.S. production will be much higher and consumption has declined because of higher prices.

Sugar production from beets in 1975 may rise by about 900,000 short tons to about 3.8 million short tons. This increase will be primarily due to additional acreages in California, Idaho, Washington, and Minnesota. Some acreage formerly diverted from sugarbeets to cotton, soybeans, wheat, and corn is being brought back to beets this year in response to more favorable prices. An increase is expected in production of sugar from cane in 1975 as the hurricane in Louisiana reduced 1974 production somewhat. Production for Hawaii and Puerto Rico has stabilized.

Since the expiration of the U.S. Sugar Act at the end of 1974, there have been no country quotas or acreage restrictions. The excise tax expired on June 30, 1975. A Presidential proclamation established a global, first-come, first-served quota of 7 million short tons, raw value. Imports can be on a raw or refined basis. With the demise of the Act, U.S. and world prices coincide. U.S. sugar production will depend largely on how prices for other commodities compare with sugarbeets. On the consumption side, use of corn sweeteners undoubtedly will make further inroads.

Current technologies have maintained high production levels in most U.S. production areas. Further application of these technologies could increase U.S. production by 10 percent. New technology to broaden the production areas is important for further increases.

Sugarbeets--Sugarbeets are grown on 1.2 million to 1.5 million acres in the United States. This annual root crop is grown primarily as a raw material for commercial sugar extraction. The leafy green tops and the crown (top part of the V-shaped root) are removed from the roots in harvesting. In some areas, tops are fed to cattle in fresh or ensiled form; in other areas they are used as a mulch. Beet pulp and beet molasses, the two byproducts from the extractive process, are also fed to cattle.

Major sugarbeet growing States include California, Colorado, Idaho, Michigan, Minnesota, North Dakota, Nebraska, and Washington. In all, 18 States grew sugarbeets in 1974.

The average sugarbeet yield in recent years was 20 tons per acre compared with 15 tons immediately after World War II. While yields have increased in recent years, there is considerable variation among areas, from 25 tons or more per acre in California and Washington to as low as 12 tons per acre in bad years in Minnesota and North Dakota.

Even so, it is not absolute yields per acre that determine where it is profitable to grow sugarbeets in the United States; it is the advantage relative to alternative crops. Except for the Red River Valley, Michigan, and Ohio, all areas are irrigated. In many of these areas, other crops are frequently more profitable, and thus sugarbeets acreage declines accordingly. But in the Red River Valley where only a few crops are commercially grown, sugarbeets are frequently the most profitable alternative. In recent years, acreage has been expanding in this region, while it has been contracting in some other regions.

About 30 percent of the U.S. sugar supply comes from sugarbeets grown in this country and processed into refined beet sugar in factories. Sugarbeets must be grown with other crops in rotation only once every 3 or 4 years. Sugarbeet growers have received Government payments since 1934 under the U.S. Sugar Act, which expired on December 31, 1974.

There is no doubt that the U.S. sugarbeet industry can continue to thrive and grow under some type of Government protection. How much of the industry can survive under free competition, in which there would be no economic limits on sugar imports, is not known. If any area could survive competitively, it would be the Red River Valley, and perhaps the Northwest United States. Growers can, with difficulty, switch to alternative crops; but processors can do little else with their factories except process sugarbeets into refined beet sugar.

While neither yields per acre nor recoverable sugar contents have increased very much over the years, there has been increased mechanization and reduced fieldworker requirements in the sugarbeet areas. Fieldworker requirements to grow a ton of sugarbeets fell from about 6 manhours per ton immediately after World War II to less than 2 manhours in recent years. Correspondingly, the number of sugarbeet fieldworkers fell from more than 100,000 in the early 1950's to less than 20,000 in recent years.

The decline in number of workers and increase in fieldworker productivity are related to the two "M's"--use of monogerm seed and mechanization. The impact of the latter is self-evident, especially in the harvesting operation. And monogerm seed, which yields only one plant, has virtually eliminated the need for hand thinning and hoeing.

With a decline in number of fieldworkers and an increase in use of monogerm seed and mechanization, there has been a decline in the number of farms growing sugarbeets. There were more than 30,000 farms in 1950 and 1951 while in recent years the number has declined to less than 12,000. With a decline in the number of farms and some increase in acreage from the late 1940's, there has been a substantial increase in harvested acreage and production of sugarbeets per farm over the years.

All areas that grow sugarbeets are physically capable of producing more sugarbeets, but this would require new mills or expansion of existing mills.

If U.S. beet sugar production expands to more than 30 percent of U.S. consumption, most of this extra production would have to be sold east of Illinois. The additional shipping costs would lower additional net revenues and might even reduce total net income to sugarbeet processors and growers. The processors and perhaps some of the growers seem aware of this. At this point, it seems unlikely that the U.S. sugarbeet/beet sugar industry is economically motivated to produce on a consistent long-run basis much more than 30 percent of U.S. sugar requirements.

Sugarcane--Sugarcane is a tropical and subtropical grass crop grown for its sugar content which is commercially extracted from the juice in the stalks. Because sugarcane does not breed true from seed, it is normally propagated by planting cuttings (cane stalks cut in short lengths) of selected canes.

Bagasse (sugar cane pulp) and cane blackstrap molasses are two by-products derived from processing sugarcane. Cane molasses is fed to cattle. Bagasse is used to fire boilers in raw cane mills, particularly where competing fuels are more expensive. It is also used in producing wallboard and paper products.

Sugarcane is grown commercially for sugar production in Florida, Louisiana, Texas, Hawaii, and Puerto Rico. It was grown in the Virgin Islands prior to 1967.

In Louisiana, sugarcane has been grown commercially since 1770. In Florida, much of the cane is grown near Lake Okeechobee which tempers

the cold winds that blow irregularly through the area. Yields vary from 30 to 38 tons per acre, depending on weather.

In Texas, sugarcane has been grown commercially since 1973, following an absence of several decades after production ceased in the early 1920's. The yields are higher than in Florida.

In Hawaii, sugarcane has been grown commercially since before the turn of the century. The cane normally grows for 24 months before it is harvested. In the late 1960's, yields averaged close to 100 tons per acre, but in the early 1970's they declined to about 90-92 tons per acre.

As in Hawaii, sugarcane has been grown in Puerto Rico since before the turn of the century. The cane is normally harvested after 12 months, occasionally after 18 months. In earlier years, yields varied between 30 and 35 tons per acre, but since 1971 they have slipped below 30 tons. The recoverable sugar content which used to exceed 10 percent has fallen below 8 percent since 1970.

While some sugarcane is planted every year in the United States, not all the acreage for harvest is planted the same year. The first year's planted cane has the highest yield after which each successive crop ("ratoon") declines in yields. After 1 to 3 years of additional crops, the area is plowed up and replanted to increase yields. All of the producing areas are mechanized except for some hand cutting in Florida and Puerto Rico. Because of the injury to sugarcane plants from mechanical harvest, cane is now replanted more frequently than formerly.

The domestic cane area normally provides about 25 percent of the U.S. sugar supply. Sugarcane growers have received conditional payments since 1934 under the U.S. Sugar Act, which expired on December 31, 1974.

There is little doubt that the domestic sugarcane industry could continue to exist and perhaps grow somewhat under some type of Government program. How much of the domestic industry could continue to survive under free competition, which removes economic limits on imports, is not known. If any domestic areas could survive, they would most likely be part of the Florida industry and perhaps Texas.

Raw cane sugar mill operators can do little with their factories except to process sugarcane juice into sugar.

Only in Louisiana and Florida has there been much, if any, increase in sugarcane yields over the years. Conversely, yields per acre have definitely declined in Hawaii and Puerto Rico. In Puerto Rico, the recoverable sugar content has also declined.

The big offset in domestic sugarcane production has been a sharp decline in fieldworker requirements as a result of mechanization. The number of fieldworkers in all domestic sugarcane areas has declined sharply from earlier years. In Puerto Rico, it now takes slightly more than 4 manhours to produce a ton of cane compared with more than 10 hours after World War II. In Louisiana, the decline has been from more than 8 to slightly over 2. In Florida, it now takes slightly more than 1.5 manhours to produce a ton of cane compared with nearly 6 immediately after World War II. In Hawaii, only slightly more than 1 manhour is needed to a ton of cane, compared with about 3.5 manhours in 1946-48.

In Puerto Rico, there would seem to be only a limited potential for expansion of sugarcane acreage. Alternative employment and alternative land uses appear more profitable than sugarcane. This is not to say there will not be some increase in Puerto Rican sugarcane in the future, but it would be limited.

In Hawaii, only about 200,000 to 250,000 acres can be used for sugarcane. Not only is the land area physically limited, but urban encroachment, particularly on Oahu as well as on the other islands to a lesser extent, will likely result in less land use for sugarcane in future years.

In Louisiana, there is also a limited area of land available for sugarcane. Thus, any expansion in Louisiana would likely be limited, but not to the same extent as in Hawaii or Puerto Rico.

Additional areas in Florida and Texas can be used to grow sugarcane. In either case, additional raw cane sugar mills would have to be built for processing. At present there are no plans for future mills.

RESEARCH NEEDS

The following were identified as the important problems that require research related to sugar.

Rank
Order

Production

1 SP Develop early-maturing, high-sucrose, high-tonnage sugarcane varieties with cold tolerance, restubbling ability, and adaptability to mechanical harvesting to increase productivity, lower production costs, and extend the crop cycle.

Rank Order		
		Production (continued)
3	SP	Find sources of pest and virus resistance and incorporate them into new sugarbeet varieties with high sucrose and yield potential for different production areas.
5	SP	Develop germplasm and practices to improve sugarbeet seed germination and to encourage faster and more vigorous emergence.
7	SP	Increase physiological and biochemical knowledge of sugarcane in order to improve sugar content and quality, biological pest control, and plant vigor and tillering.
7	SP	Study pathogenic agents affecting the sugarbeet and develop control measures.
9	SP	Develop sweet sorghum varieties that are high in sucrose, with good juice characteristics, that resist pests and can be mechanically harvested.
9	SP	Develop ways to increase sugarbeet production under adverse conditions such as cool soil temperatures, saline soils, low water supply, and reduced nitrogen.
11		Develop sugarbeets with a root shape more amenable to harvesting and cleaning.
14	S	Develop improved mechanical sugarcane harvesters.
14	SP	Develop techniques to modify sugarcane maturity and improve quality.
16		Improve technology for control of sugarcane diseases.
17		Develop better understanding of nutrient requirements, improve fertilizer formulations, and develop more efficient application techniques for better utilization of available fertilizers.
18	SP	Develop more reliable, safe, and selective herbicides and growth regulator treatments for sugarbeets.
20		Collect, maintain, and evaluate germplasm of Saccharum and its wild relatives.

Rank Order		
		Production (continued)
	S	Develop integrated pest management systems.
	S	Develop cultural practices for sweet sorghum to increase production and allow for mechanical harvesting.
	S	Develop new or improved means of preventing sucrose losses from inversion and frozen or damaged cane.
		Marketing and Processing
4		Determine the complete chemical composition of sugarbeets and process liquors and relate the effects of nonsucrose chemicals to sugarbeet quality and processing characteristics.
6	SP	Develop basic breeding lines and cultural practices for sugarbeets that will improve processing quality at harvest and after storage.
12	SP	Develop new ways to handle beets following harvest and in storage that will maintain harvest quality and reduce losses of sugar.
19	S	Improve techniques to remove impurities of raw sugar that interfere with the purity of refined sugar.
	S	Develop a model system to provide information on sugar supply and demand, price stability, and producer returns--with and without a "Sugar Act."
	S	Evaluate the possibilities of processing sorghum in sugarcane factories as a supplementary operation.
	S	Determine the potential for expanded U.S. domestic sugar production, and the ability of U.S. producers and processors to stay in production at lower prices.
	S	Evaluate the processing quality of new varieties of sugarcane.
		Consumer Needs
2		Develop workable guidelines to determine the significance to human health of minute residues of chemical substances in all food products.

6.1 VEGETABLES

Objective: To provide an adequate supply of high-quality, safe, and nutritious vegetables with high consumer acceptance, consistent with good agricultural practices and environmental concerns.

SITUATION

Vegetables occupy a key place in the American diet, as some of them along with fruit are the major sources of vitamin C, and nearly all contribute substantial quantities of other vitamins and minerals required for an adequate diet.

A recent USDA-SAES study identified crops that contribute 5 percent or more of essential nutrients to the average American diet (or 10 percent or more to the diet of identifiable ethnic groups) as follows:

	Data from Senti Committee						
Crop	Protein	B_6	Vit. A	Thiamin	Niacin	Vit. C	Mg
Wheat	X	X		X	X		X
White potatoes		X		X	X	X	
Carrots			X				
Tomatoes			X			X	
Sweet potatoes			X				
Peanuts					X		
Oranges						X	
Cabbage						X	
Dried beans				X			X

It is evident that vegetables are major contributors to the health needs of this country. Minerals were excluded from this list since producers have relatively little control over mineral content of a crop beyond that required to produce an economic return.

As U.S. incomes and population have increased, so has the demand for fresh and processed vegetables. Excluding potatoes and sweet potatoes, more than 23.5 million tons were produced in 1974 against 18.4 in 1960. Nearly all this gain comes in the processing sector. Domestic production of fresh vegetables increased only moderately in the past 14 years.

Overall per capita consumption of vegetables has increased. However, per capita consumption of fresh vegetables dropped to 100 pounds annually, despite an increasing volume of Mexican imports (imports equal roughly 6 percent of the U.S. fresh vegetable supply but run as high as 20 to 25 percent for fresh tomatoes).

PER CAPITA CONSUMPTION TRENDS
(pounds, fresh equivalent)

	1960	1974
Fresh*	105.7	100.4
Canned	81.7	100.5
Frozen	14.9	20.6
Total	202.3	221.5
Potatoes	103.4	122.5
Sweet potatoes	7.1	5.2
Grand total	317.8	349.4

*Excludes melons.

In an effort to remain competitive with imports and to compete with other foods in U.S. markets, the vegetable industry has made good progress in developing new varieties of improved quality and disease resistance and new varieties that extend the market season, and it has made substantial progress in using new varieties that are adapted to mechanized planting and harvesting.

Mechanized harvesting has made great strides in this country, especially for processing vegetables. The acreage for crops that cannot be harvested and handled mechanically will probably be greatly reduced in a matter of only 10 to 20 years. Otherwise, costs to the consumer will be high in comparison with items such as snap beans and tomatoes which are grown, harvested, and canned with a minimum of hand labor.

In brief, efficiency in U.S. vegetable production has been largely related to improved varieties, cultural practices, disease control, and mechanized handling techniques. For some crops, as with those two mentioned previously, great advances have been made. For other vegetables, notably asparagus, peppers, melons,and market cucumbers, substantially more progress must be made. In some instances, the U.S. vegetable industry can no longer compete with imports from Mexico of winter and spring fresh vegetables and similar crops that require large inputs of labor to grow, harvest, and pack.

In the next few years, further production and handling research is needed to keep the industry competitive and to keep retail prices as reasonable as possible. In addition, a reduction in losses between the producer and consumer is necessary to keep marketing costs at a minimum. Also, as several observers have pointed out, neither the U.S. vegetable industry nor various government agencies and land-grant institutions have extensively studied or evaluated the social costs associated with the further application of technology.

Another problem on the production side relates to disease and insect and weed control. Commercial firms have become reluctant to invest time and resources into new product development that would have limited application to one or two vegetables. With sharply increased research and development costs and with more rigorous clearance procedures required, industry research efforts must be supplemented by grower, government, and university efforts to find new biological controls or develop a specialized fungicide or pesticide for one or two vegetable crops.

In summary, development of new varieties and production practices, resolution of labor problems, reduction of marketing losses, competitive market forces, and competition with field crops for use of available cropland and labor--but not the lack of available cropland--will largely determine the scope and character of the U.S. vegetable industry of the 1980's.

Among the pressing problems faced by the industry is the development of varieties with wider adaptation. For example, concentration of the tomato processing industry in California is potentially troublesome. Some California tomato growers have ceased crop rotation because of land shortages. The processing of tomato production is declining in other States because varieties are not adapted to environmental conditions in these areas.

More attention must be given to the problem of energy conservation. Energy costs are having a profound influence on the cost of producing, processing, distributing, and preparing vegetables as well as other foods.

RESEARCH NEEDS

The following were identified as the important problems that require research related to vegetables.

Rank
Order

Production

1 SP Develop basic new methods of improving yields, such as nitrogen fixation and improved photosynthetic efficiency.

Rank Order		
		Production (continued)
2	SP	Develop varieties, machinery, and methods for mechanized production.
2	SP	Develop new and improved pesticides and application methods particularly for minor crops.
4	SP	Develop and maintain germplasm banks to facilitate development of pest resistance and for study of host-parasite interactions.
5	SP	Develop improved vegetable breeding approaches such as incorporation of a wider base germplasm (more heterosis) into new varieties.
5		Develop research to determine long-term effects of herbicide buildup in soil on subsequent plant growth.
5		Increase research effort on irrigation to reduce salt buildup and improve salt leaching.
8	SP	Develop integrated pest control systems, including management practices and crop sequences, to minimize the need for chemicals.
8	SP	Minimize the environmental hazards of agricultural chemicals used in vegetable production.
8	SP	Develop energy-efficient, high-yielding, high-quality, pest-resistant varieties of vegetables, especially for home gardens.
8		Develop an understanding of vegetable production problems and potentials in tropical regions of Latin America, the Pacific Ocean areas, Asia, and Africa and of opportunities for U.S. involvement.
15		Determine means of building up organic material in soil by use of selected plants (even weeds).
18	SP	Determine the plant factors that affect vegetable quality in order to meet consumer needs and regulation requirements.
18	S	Increase understanding of vegetable genetics and physiology, with emphasis on crop performance.

Rank Order

Production (continued)

18 Develop increased research on crop rotation and cover cropping for vegetable production.

18 Arrange more frequent meetings of research, industry, and production groups.

18 Develop vegetable breeding approaches that are more logically and regionally based.

S Develop nonchemical means of insect control such as repellants, predators, and insect pathogens.

S Determine the roles of genetics and environment in pest resistance and the factors involved in host-parasite interactions, including survival of pathogens.

Marketing and Processing

8 SP Develop processing methods to get greater recovery from the raw product and to lower processing costs and energy consumption.

15 SP Determine new uses of processing wastes for feed, fertilizer, or byproducts.

15 Develop means for converting vegetable wastes to acceptable food products through feeding of livestock or poultry.

18 SP Develop methods to better maintain nutritional quality of vegetables during transit and storage, such as control of bacteria and fungi.

18 S Develop processing methods to capture more of the nutritional value of products.

18 Develop research to improve efficiency of vegetable transportation.

S Develop improved postharvest handling of fresh vegetables to maintain quality and appearance and to reduce losses.

S Improve storage and shelflife of vegetables through use of natural inhibitors, modified atmospheres, and optimum temperatures and humidities.

Rank Order		
		Consumer Needs
8	SP	Determine the nutritional qualities of all vegetables and the roles they play in human nutrition; improve those qualities by breeding and cultural practices.
8		Develop guidelines to evaluate the significance to human health of minute residues of chemical substances in all food products.
	S	Identify naturally occurring toxicants and determine their genetic behavior.

6.2 POTATOES

Objective: To meet continuing domestic and world needs for safe, high-quality potatoes and potato products with higher consumer and user acceptability, consistent with sound management of resources and environmental concerns.

SITUATION

United States potato production has trended upward in recent years--from a low in 1965 of 291 million hundredweight to a high of 337 million hundredweight in 1974. This reflects a strong demand for processed products despite declining requirements for fresh markets. Further decline in fresh market use is expected the next few years, but total use is likely to be well maintained since potato products are proving popular, convenient, and economical food choices. Franchised food outlets use frozen fries as one of their profitable mainstays; dehydrated products are finding everwidening institutional and home use. Convenience and confection type potato products will increase at home and abroad.

While total production has been increasing, the total acreage committed to potato production has declined. Potato production is subject to extreme fluctuations from one season to the next, with resultant market price fluctuations. Although average yields have improved somewhat (26 hundredweight per acre between 1965 and 1972), they have not been as dramatic as yield increases experienced in many agricultural commodities. The potential for expansion of production and processing capabilities exists to an extremely high degree, especially in the Pacific Northwest and the Red River Valley.

Potatoes are one of the most efficient and nutritious food crops man can grow. They supply more calories per acre than all but a very few crops. (This is a result of heavy yield per acre, not because potatoes are a high calorie food.) It is just as important to note that this vegetable contributes substantial vitamin C to the diet and is also a rich source of niacin, thiamin, phosphorous, and iron in American diets today. It is no accident that in countries where the potato is extensively grown and where per capita consumption is high, nutritional deficiencies tend to be minimal. Despite the important nutritional contribution being made by the potato, current research efforts are aimed at increasing the vitamin C and protein contents of the tuber. The value of potatoes for protein nutrition should not be underrated. If an adult male consumed all the calories he needed to maintain his body weight by eating only fresh potatoes,

he would obtain all the protein he needs and it would be well balanced. Thus, potatoes are important nutritionally in wide areas of the world where it is possible to grow this rather cosmopolitan food. Except for the humid tropics, this crop can be grown in many locales including some where food is scarce.

The United States is one of the world's leading potato producers but our annual production is usually smaller than that of West Germany and Poland, and it is dwarfed by Russian tonnage. Our prospects for expanded exports are not great, although a concerted attempt is being made to ship dehydrated products to several Asian countries bordering on the Pacific Ocean. Fresh shipments overseas have been small and will continue to remain so. The United States could increase exports and provide a much-needed service by developing a seed potato industry for areas where table stock can be produced but where high-quality seed production is not possible.

The major thrust of variety research is to develop early-maturing, high-yielding, pest-resistant, high-quality processing, and fresh market types for the various production areas. Early maturing varieties are needed that will recondition better from cold storage and that are designed for the frozen french fry market. Production research now underway appears adequate from a surface viewpoint--however, indepth studies reveal many inadequacies in the areas of virology, plant physiology, pathology, food science, equipment engineering, economics, and crop management.

Although the technology for processing potatoes and its products has made tremendous strides in providing products with a high degree of U.S. consumer acceptability, developmental research to fully utilize the nutritional qualities of the potato and to blend in taste factors of diets normally found in underdeveloped and starving areas of the world is almost nonexistent.

RESEARCH NEEDS

The following were identified as the important problems that require research related to potatoes.

Rank
Order

Production

1 SP Develop new varieties with better nutritional value, better processing characteristics, improved pest resistance, and adapted to a wider range of environmental conditions.

2 SP Develop cultural practices to lower production costs.

Rank Order		
		Production (continued)
3	SP	Improve approaches to potato breeding, such as incorporating a wider base of germplasm (more heterosis) into new varieties.
4	SP	Develop more efficient control for potato diseases.
4	SP	Develop methods to reduce losses of potatoes in storage for long periods of time.
7	SP	Develop integrated pest management systems consistent with economic production of high-quality potatoes.
7	SP	Develop more efficient methods of inducing maturity and decreasing bruising during mechanical harvesting, storage, and handling.
7	SP	Devise protection, including resistant varieties, against pests not now in the United States, such as additional aggressive races of the golden nematode.
7		Develop research to determine long-term effects of herbicide buildup in soil on subsequent plant growth.
12		Determine the physiological or biochemical basis for tuberization.
16		Investigate means of propagating potatoes from true seed.
16		Determine means of building up organic materials in soil by use of selected plants (even weeds).
	S	Develop improved pesticides that are specific against target species, degradable, and of low mammalian toxicity and application methods.
	S	Improve photosynthetic efficiency and nutrient uptake.
		Marketing and Processing
4	SP	Develop low-cost, efficient ways to use processing wastes for food, feed, byproducts, or other economic purposes.
7		Develop research to facilitate the export of potatoes for seed, particularly the relaxation of existing trade barriers.

Rank
Order

Marketing and Processing (continued)

13 SP Develop more efficient processing methods to get more recovery from raw products while using less energy and processing oils.

13 SP Improve technology to maintain quality and appearance of fresh market potatoes and to reduce losses in transit and storage.

16 SP Develop more acceptable products from surplus potatoes that can be easily transported and stockpiled as a food resource.

S Develop more desirable flavor in potato varieties and stabilize flavor in dehydrated potatoes.

S Improve packaging methods or other systems to reduce transit losses.

S Develop methods to biodegrade potato wastes that are not acceptable for feed, fertilizer, or other byproducts.

Consumer Needs

13 SP Develop concentrated, highly nutritional products acceptable to both developed and underdeveloped countries in order to exploit export opportunities.

19 SP Determine consumer preferences in foreign markets for potato products.

S Determine more precisely the benefits of potatoes in human nutrition and ways to prepare and use potatoes to maintain those benefits.

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6.3 DRY BEANS AND PEAS

Objective: To provide an adequate supply of dry beans, dry peas, and other pulse crops as a source of high-quality, low-cost protein, consistent with good agricultural practices and consumer preferences and well-being.

SITUATION

Grain legumes (pulses) are valued in diets because they are: High in protein. High in lysine. A fairly good source of thiamin, riboflavin, and niacin. The basis of foods with a wide range of flavors and textures that appeal to almost everyone.

Dry Beans

United States consumption of dry beans has been roughly 14 million hundredweights in recent years. Production has fluctuated, however, from as low as 15.9 million hundredweight in 1971 to a record 20.9 million hundredweight in 1974. This great fluctuation in production relative to domestic demand has resulted in considerable variation in the quantity of dry beans available for export.

The substantial changes in export volume every year have limited the opportunity to develop regular outlets abroad. A consistent level of production could be the basis for developing more regular overseas outlets.

Stabilization of production and improved nutritional value of dry beans would be of value to the people of the United States. In 1965, about half the packaged dry beans were used by those whose incomes after taxes fell below $5,000 a year (4). Low-income people need a low-priced food in their diet to supply protein, and dry beans have long been that food.

Dry bean production is centered in areas that have considerable agricultural diversity. About 40 percent of the U.S. production comes from the thumb area of Michigan. Other areas of concentration include California, the Magic Valley of Idaho, the irrigated valleys of the Nebraska Panhandle, and Colorado.

Variations in production resulting from the number of acres planted in these regions is a function of each farmer's assessment of the profitability of beans versus other cropping alternatives. In the West, competing crops include sugarbeets, corn, potatoes, wheat,

alfalfa, and, in California, vegetable crops in some years. Not all of these choices are directly related to price. Farmers also consider the level of production, the certainty of obtaining a crop, production expenses, ease of handling, work schedules, and marketing facilities. As a short season, relatively low-cost-input crop, beans compete in most of these considerations very well. They seem, however, to be more vulnerable to disease and insect pests than do crops like corn or soybeans, so this consideration makes dry beans less attractive to growers. Among the most serious problems are bacterial blights and wilts and fusarium root rot.

Protein of beans has a relatively low efficiency when fed to animals, and it is assumed that humans respond in a similar way. Nutritionists attribute the low value of bean protein to its limited content of essential amino acids, principally methionine and to the presence of antimetabolic factors such as trypsin inhibitors. Nonetheless, the protein level of dry legumes is relatively high, approximately double that of cereal grains. Because their respective proportions of certain essential amino acids are complementary, dietary combinations of dry legumes and cereal grains frequently yield a mixed protein which is superior to that of either legumes or cereals consumed separately. However, there is need for improvement of legume protein quality, as legume proteins are not easily digested.

In addition to a digestion-resistant protein fraction, beans also contain significant quantities of indigestible constituents and provide substrate for bacterial fermentations in the lower intestinal tract. The indigestible portion represents not only nonavailable and wasted nutrients, but it is generally recognized as a principal cause of gastrointestinal gas and the accompanying discomfort experienced by consumers of unrefined dry legumes (2,3). No doubt, domestic and world demand for beans would increase markedly if this flatulence problem were overcome and if quick-cooking beans were developed.

The impact of the high-lysine corn discovery has emphasized the search for genes that would increase the amount of limiting essential amino acids in proteins of plant origin. Methionine is often suggested as the appropriate one to search for in beans. Kelly et al. have suggested a microbiological assay for available methionine as a screening tool for improving bean protein by plant breeding methods (1).

Dry bean yields have not improved over the years as have yields of wheat, rice, corn, and other cereal crops. Further, yields of dry beans have increased less than yields of snap beans. Dry bean yield trials have indicated that current varieties do not give higher yields in response to either high fertilizer rates or closer spacing (more plants per unit of land area).

Dry Peas

About 97 percent of the U.S. commercial dry pea production and 100 percent of the U.S. production of lentils are grown in the Palouse area of Washington and Idaho. In the past few years, pea production has ranged from 676 million pounds in 1971 to 346 million pounds in 1974. Production of lentils in recent years has averaged about 100 million pounds annually. Considerably more acreages of these two crops could be grown if there were sufficient markets available to handle the supply.

The U.S. consumer's interest in a low-cost source of protein has increased the U.S. consumption of these products, especially during the past few years. However, the biggest market still is for export. About 65 percent of the dry pea production and 70 percent of the lentil production is exported to more than 40 countries in Asia, Europe, and South America. The United States is one of the world's largest exporters of lentils and dry peas, although we produce only about 3 percent of the total world production. Most countries that grow these crops do not produce enough for their own needs and, therefore, must look to foreign sources or go without.

RESEARCH NEEDS

The following were identified as the important problems that require research related to dry beans and peas.

Rank Order		
		Production
1	SP	Increase understanding of dry beans genetics and physiology with emphasis on crop performance.
2	SP	Develop efficient direct harvesters that thresh with little loss of beans in the field, and develop bean varieties suitable for mechanized harvesting.
2	SP	Develop new approaches to bean breeding, such as incorporation of a wider base germplasm (more heterosis) into new varieties.
4	SP	Develop bean varieties with higher protein content and improved protein quality.
4	SP	Develop germplasm with increased yield potential and breed it into commercial varieties.

Rank Order		
		Production (continued)
4	SP	Search for germplasm to reduce flatulence.
4		Develop a domestic center of excellence for dry bean research which would focus on basic principles of breeding, plant growth, and development which would generate knowledge for the use of bean scientists throughout the world.
9	SP	Improve plant growth and reproduction by such means as nitrogen fixation and more efficiency of fertilizer use.
10		Reduce the genetic vulnerability of dry beans and peas.
11	SP	Discover rapid, dependable techniques for evaluating essential amino acid content of raw beans as an aid in genetic improvements.
11	SP	Improve bean tolerance to environmental stresses such as air pollution, herbicides, adverse soil conditions, cold, heat, and drought.
13	SP	Investigate the nature and genetic control of nonspecific resistance to pests and pathogens.
19		Develop varieties suitable for multiple uses, such as for forages as well as for edible purposes.
	S	Develop integrated pest management systems consistent with economic production of high-quality dry beans.
	S	Study pest resistance and factors involved in host-parasite interactions, including effects of the environment on disease development and survival of pathogens.
	S	Determine how much pathogens vary and the mechanism of variability.
		Marketing and Processing
13	SP	Develop new and improved processed products with quality, convenience, stability, wholesomeness, and low cost.
13	SP	Improve postharvest handling of dry beans at all levels.

Rank
Order

Consumer Needs

4	SP	Find methods of reducing flatulence caused by legume consumption.
13	SP	Discover means to reduce or eliminate growth inhibitors and hemagglutinins.
17	SP	Develop information required by dry bean producers to meet GRAS requirements under the pure food and drug regulations.
18		Evaluate nutritional quality, market acceptability, agronomic productivity, and dietary usefulness in a systems approach.
	S	Develop more convenient dry bean products for consumers, such as dry bean powers or precooked products.
	S	Improve flavor and food quality.

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7.1 FRUITS AND NUTS

Objective: To develop improved production and distribution systems and maintain an adequate supply of competitively priced, high-quality fruit and nut crops, consistent with good agricultural practices and environmental concerns.

SITUATION

Fruits and nuts are grown on about 1 percent of our principal cropland but account for 6 percent of the total farm value of principal crops. In 1973, Americans consumed 1,438 pounds of food (retail weight equivalent) of which 155 pounds (10.8 percent) was in the fruit category. The fruit and nut industry has undergone significant changes during the past two decades.

Trends in the production of fruits and nuts since 1945 have included: Increased output. Declining number of farms. Changes in the location of production. Improved varieties. New processed products. Improved technology in producing, harvesting, and processing. Shifts in consumer preferences. Improved packaging. Better facilities for storage and transportation.

Although fruit production has trended upward, there have been shifts in producing areas. The South Atlantic and Pacific regions had the largest increases in total fruit acreage and the largest number of farms.

Advances in production technology and increased use of capital and fertilizer have contributed to a clear trend toward fewer, larger, and more efficient farms. As fruit farms have been getting larger, they have also become more specialized and commercialized. However, in many places--particularly in the Eastern States--there has been an increase in plantings for "pick-yourself" operations for fruits, especially berry crops and dwarf tree fruits. These operations are generally small.

The tendency toward specialization is suggested by the concentration of fruit production in a few States. In 1973, seven States (California, Florida, Washington, Texas, New York, Michigan, and Oregon) accounted for 90 percent of total U.S. fruit and nut production.

During the past two decades, production per acre for fruits has increased considerably. Yield per bearing acre for all fruit increased from 5.5 tons in 1950-52 to 7.5 tons in 1970-72, a gain of 36 percent. The increasing yield illustrates the effect of

advances in production technology both in cultural practices and harvesting techniques.

A striking shift in the use of both citrus and deciduous fruits has occurred during the past two decades. The importance of the fresh market for fruit crops has decreased rapidly. The proportion of total fruit sales for fresh use declined from about 45 percent in 1950-52 to 35 percent in recent years.

Changes in consumption patterns generally reflect the interaction of such factors as production, price, income, population, convenience packaging, consumer preference, and taste. The annual per capita consumption of all fruits, fresh and processed combined, on a fresh equivalent basis, declined from a record high of 225 pounds in 1946 to about 200 pounds in 1973. In 1973, more than half (104 pounds) was from citrus fruit.

Per capita of fresh fruit consumption fell from 111 pounds in 1950-54 to 76 pounds in 1973. The decrease in fresh citrus consumption was more than that of deciduous fruit. Fresh citrus consumption fell from 44 to 28 pounds since the early 1950's and that of deciduous fell from about 67 to 58 pounds.

In contrast, per capita consumption of processed fruit rose sharply from 87 pounds in 1950-54 to 123 pounds in 1973. This was due mainly to the sharp increase in processed citrus consumption. Consumption of processed deciduous fruit has remained relatively stable.

Deciduous fruit production to 1985 probably will increase at a rate slightly less than that of population growth, but total citrus production can be expected to increase considerably more than population.

United States commercial production of tree nuts has trended upward during the past three decades. In 1973, a record crop of about 465,200 tons of tree nuts was produced. The 1960-64 average production was 277,563 tons, and this included the previous record crop of 340,000 tons in 1963.

Traditionally, pecans and walnuts have been the largest domestic tree nut crops, but during the 1960's there was a rapid increase in bearing acres and production of almonds, which now account for about one-third of the total production. This compares with 15 percent of the total crop in the 1930's and 20 percent in the 1950's.

Commercial acreages of almonds and walnuts are located in California; filberts and a few walnuts are located in Oregon. Pecans are produced commercially in 15 Southeastern, Southcentral, and Southwestern

States, ranging from North Carolina in the east and Arizona in the west to southern portions of Missouri and Illinois. When Hawaii became a State, Macadamia nuts were added to our domestic tree nuts. Since 1970, pistachio nuts have been planted extensively in California and Arizona. These will be important domestic tree nuts in the years ahead.

Research and technology have made important contributions to the fruit and nut industries. The introduction of improved varieties with increased yields and consumer acceptance have been particularly significant. Control of insects, diseases, viruses, and weeds has greatly reduced losses and improved fruit and nut quality at harvest. High-density planting systems and other improved cultural systems have also contributed to improved yield and quality. The use of controlled atmosphere storage has greatly extended the storage life of many fruits, and fresh apples are now available the year round. Increasing uses have been found for growth regulators, and mechanization of fruit harvest has accelerated in recent years.

RESEARCH NEEDS

The following were identified as the important problems that require research related to fruits and nuts.

Rank Order		Production
1	SP	Reduce tree losses of major fruit and nut crops, such as short life of peaches in the Southeast and young citrus tree decline in Florida.
1	SP	Increase mechanization of cultural and harvest operations.
1	SP	Investigate growth regulators and their influence on growth, flowering, fruiting, fruit quality, etc., so as to better control tree physiology and increase production.
4	SP	Develop improved scion and rootstock fruit and nut varieties that are high yielding, high quality, early bearing, pest resistant, and adapted to mechanical harvesting.
4	SP	Evaluate existing regulations and controls on chemicals and equipment to remove unnecessary restrictions during production, harvesting, marketing, processing, and preservation.
6	S	Collect and maintain germplasm to provide a wider genetic base for future breeding programs.
6	SP	Increase efficiency of pest monitoring and pesticide application methods to improve timing of biological and chemical control measures for diseases, insects, nematodes, weeds, and other pests.

Rank Order		
		Production (continued)
6		Intensify basic genetic studies on fruit and nut crops.
9	SP	Cooperate with industry to develop and test environmentally safe pesticides and provide registration data.
13	SP	Improve rootstocks to minimize losses from pests, environmental stress, and replant problems so as to optimize tree densities and per-acre production.
13		Improve production, harvesting, processing, and transportation methods to reduce energy requirements.
17	SP	Modify tree training and cultural systems to increase production and make more efficient use of sunlight, land, water, fertilizers, and labor.
17		Improve waste management systems associated with production, packing, processing, and marketing.
19		Develop more efficient methods of water utilization in production, harvesting, packaging, and processing.
	S	Improve methods of control for diseases, insects, nematodes, and weeds.
	S	Investigate ways to alleviate problems in labor supply during production and marketing.
	S	Develop registration data for minor-use chemicals to increase their availability on fruit and nut crops.
		Marketing and Processing
9	SP	Develop technology for automatic handling, bruise detection, sorting, and nondestructive quality evaluation of fruit products in the processing or packing plant.
9	S	Improve packaging, handling, and transportation methods for fresh fruit to reduce losses and maintain quality.
13	SP	Develop more efficient packaging, handling, transport, and refrigeration methods for perishable fruit and nut commodities for expanding export markets.

Rank Order		
		Marketing and Processing (continued)
19	SP	Improve processing methods to minimize loss of quality and nutrients.
	S	Evaluate the effects of production and cultural systems, including maturity, on storage, quality, and nutritional characteristics of fruits and nuts.
		Consumer Needs
9	SP	Determine the role and bioavailability in human health and nutrition of fruits and nuts and their components.
16		Develop a multiresidue system of chemical analysis that is accurate, economical, and practical for everyday usage.

7.2 BEES AND OTHER POLLINATING INSECTS

Objective: To fully utilize the food-producing capacity of the honeybee and other pollinating insects by maintaining a viable and growing bee and pollinating insect industry.

SITUATION

The World

The 32 major producing countries market about 1 billion pounds of honey annually. The Western Hemisphere is the major production source. The People's Republic of China, however, is one of the major exporting countries. West Germany, Japan, and the United States are among the larger importers (2).

In Europe, North America, Australia, and New Zealand, bees have been used extensively as pollination agents for agricultural crops. In the western U.S.S.R., colonies of bees are used on several crops, particularly on cotton. Nowhere else in the world are honeybees transported for pollination purposes in numbers equal to the movement of colonies in the United States (3).

The United States

Beekeepers produce about 215 million pounds of honey annually with about 4 million colonies (4). In addition, bees and other insects are essential to the production of more than 90 crops that would not set seed or fruit unless insect pollinated (1). It is estimated that honeybees and other commercially provided pollinators are essential in maintaining $7.6 billion of the national agricultural production (5). The honey produced is worth more than $60 million (4).

Honey yield per colony has risen sharply during the past few years to nearly 58 pounds per colony. However, the number of colonies has shown a steady decline. This decline in colonies is becoming particularly critical in areas where pollination services are in strong demand.

Until the past few years, the price of honey has been discouragingly low. Also, the prices beekeepers received from pollinating services were usually too low to cover the losses in honey incurred when moving colonies from field to field. Recently the price of honey has more than doubled and prices paid for pollinating services have also risen. Nevertheless, in some locations the declining number of colonies has resulted in no bees available for pollination at any price.

The declining number of colonies is a dangerous trend, not only in regard to the production of honey, but also in regard to food produced by other crops. As monoculture expands the acreage planted to a single crop and as fields are made larger, the support vegetation for wild bees and other naturally occurring pollinators becomes scarcer. Thus, our crops are becoming more and more dependent on commercial pollination services at a time when the availability of those services is declining.

Besides the low prices, high production costs also have contributed to declining number of colonies. Among the most serious increases are the costs of poisoning by pesticides.

Furthermore, the current high prices of honey also have introduced problems for the industry. The industry is being confronted with competition by the lower cost substitutes and extenders that cannot be distinguished from natural honey by any known analytical methods.

Under good management, the national average for honey production could be doubled. Commercial queen breeders and package bee producers are the key to further genetic improvement of colonies. Seventy-five special strains of bees are currently maintained by Federal, State, and commercial bee geneticists. Mechanization has been developed for handling hives. Forty seven States require periodic inspection of colonies to prevent the spread of disease. Sugar syrup is used as a substitute for nectar in order to avoid starvation during inclement weather, but there is no substitute for pollen.

RESEARCH NEEDS

The following were identified as the important problems that require research related to bees and other pollinating insects.

Rank
Order

Production

1 SP Conduct additional research on influence of insect pollination on production and quality of insect-pollinated crops.

2 SP Protect colonies from pesticides.

2 SP Develop control and/or eradication procedures to prevent spread of the African or Brazilian bee into Central America.

Rank Order		
		Production (continued)
2	SP	Maintain and increase research on the African or Brazilian bee to minimize the impact of possible entry into the United States.
7	SP	Develop strains with improved honey production.
7	SP	Improve artificial diets.
7		Further develop basic genetic studies of the honeybee.
10	SP	Develop strains more resistant to disease and pesticides.
10	SP	Protect colonies from American foul brood.
10	SP	Improve efficiency of requeening.
16	SP	Develop strains that winter better.
16	SP	Protect bee frames from wax moth.
19	SP	Improve efficiency of queen development techniques for commercial queen producers.
19	SP	Determine effect of climate variables on queen productivity.
	S	Improve wild insect pollinator management and selection.
	S	Further improve genetic quality of package bees and queens.
	S	Develop strains with greater queen productivity.
	S	Increase availability of early queens.
	S	Develop support crops to maintain pollinators during off-season.
	S	Protect colonies from nosema disease.
		Marketing and Processing
6		Develop analytical procedures to delete honey adulteration.
10	SP	Improve methods of transporting package bees and queens.

Rank Order	
	Marketing and Processing (continued)
10	Improve procedures for transporting bee colonies.
10	Develop improved methods of sampling bulk honey.
S	Evaluate any proposed modifications in honey processing, including additives, for potential hazards.
S	Improve contractual arrangements with growers.
	Consumer Needs
2	Initiate research to establish nutritional and dietary value of honey.
16	Improve quality control procedures for honey and honey products.

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8.0 FORAGE, PASTURE, AND RANGE

Objective: To improve the economic productivity of forage, pasture, and range; to develop production systems profitable to producers; and to provide livestock and livestock products of a quality and at prices attractive to consumers.

SITUATION

The World

Grasslands and rangelands still comprise the most expansive type of vegetation on earth, even though a large percentage of the world's cultivated acreage was converted from natural grasslands. Grasslands exist over the widest range of ecological conditions of any crop, ranging from desert to humid tropics; from shallow, rocky soils to deep, fertile soils; from tidelands to alpine meadows. They are comprised of a large number of annual and perennial grasses and legumes, as well as forbs, shrubs, and trees (savanna).

While most of the world's grasslands remain unimproved, a significant portion has been converted to improved rangelands, improved pastures, and other cultivated forages. Many of the grassland areas would not support other crop cultures. Thus, forage productivity and subsequent animal consumption of this crop represent use of a renewable resource for human food consumption that otherwise would be wasted.

The forage, pasture, and rangeland areas of the world support a ruminant animal population--comprised of cattle, buffalo, sheep, goats, and horses, as well as feral deer, elk, and other wild species--that is nearly equal to the human population. The products of these livestock are of great value to the human population as a source of highly nutritious foods and for many other uses. Consumption of such products is high in both developed and developing countries, and the demand exceeds supply by a considerable amount. Consequently, the importance of lands producing forage can scarcely be overemphasized in measuring world food supplies.

Many of the world's grasslands produce far below capacity, mainly because of overgrazing and the unavailability of, or failure to apply, improved technology to forage-producing lands. The potential for developing and applying improved technology to increase grassland productivity is very great, thereby offering a great opportunity for increasing the world food supply of highly nutritious and desired foods.

The United States

Historically, American grasslands were brought under cultivation as soon as sufficient economic incentives existed; occasionally, even before. The borderline between pasture and cultivated land shifted in response to economic and population pressures. At present, about 400 million hectares (1 billion acres), or about half of the U.S. land area, is occupied by forage, pasture, and range. About 80 percent of this is rangeland in the 17 Western States that is unsuited for cultivation. Most permanent pasture land in humid areas also is not suited to cultivation. Most land harvested for forage is tillable, but the greatest economic opportunity for its use is in forage production for beef and dairy enterprises. Pasture, range, and forage provide 73 and 63 percent of the feed units consumed by beef and dairy cattle, respectively, and about 89 percent of those consumed by sheep. Their value is estimated to represent half the cash receipts from beef cattle and one-third of the cash receipts from dairy cattle. Because beef and dairy cattle are two of the four top farm income-producing commodities in 80 percent of the States, the immense value of forage, pasture, and range can be easily envisioned. Ancillary values in addition to direct value in food production include conservation of soil and water resources, provision of wildlife habitats and recreational opportunities, recycling of agricultural and nonagricultural wastes, and enhancement of the environment.

United States per capita beef consumption rose from 62 pounds in 1952 to 116 pound in 1972 but fell slightly in 1973. Future supplies of red meat and dairy products at affordable consumer costs will depend largely on how effectively we increase forage production and utilization and reduce grain feeding.

At least 90 grass and about 30 legume species are important for grazing and harvested forage production. This is both a tremendously complicating factor and a challenging opportunity in management of forage lands and in genetic improvement of forages.

Recent world food shortages and rising foreign demand for U.S. grains have reduced the amounts of grain that can economically be fed to cattle, and consequently increased dependence on forages for beef and dairy cattle production. Greater quantities of higher quality forage will be needed to maintain production levels of beef and dairy products. There are only limited opportunities for alternative uses of rangeland, so that most of it will remain in forage production.

The present effort in forage, pasture, and range research amounts to 440 scientific man-years. It is carried out by universities in all States and at numerous locations of the USDA and other Federal

agencies. The effort is distributed over a large number of forage species, which are produced under a wide range of environmental situations and used in many types of enterprise.

Research and technology have made major contributions toward sustaining the rapidly expanding beef cattle populations and increasing productivity per dairy cow. Improved range grazing systems permit heavier stocking rates without deterioration of range condition. Brush control and range seeding have restored millions of hectares of range to a productive condition. Improved forage varieties in a few species have increased the yield of forage of improved quality, with reduced dependence on pesticides. Fertilizer practices have provided considerable increase in forage productivity. Better grazing and harvesting management has resulted in significant increases in animal product per hectare. However, harvesting and storage practices have shown little improvement in the past 20 years and represent a major source of loss in productivity.

RESEARCH NEEDS

The following were identified as the important problems that require research related to forage, pasture, and range.

Rank
<u>Order</u>

8.1 <u>Harvested Forages and Seed Production</u>

1 SP Collect, assess, and maintain germplasm of forage species for current and future use.

2 SP Develop varieties with multiple resistance to insects, diseases, and nematodes.

3 SP Develop grasses and legumes high in protein, digestibility, palatability, and intake potential.

3 Produce higher yielding, higher quality forages on all classes of land with particular emphasis on <u>marginal land</u>.

5 SP Develop grasses and legumes that are free of or have low concentrations of problem components (bloat-causing agents in legumes, alkaloids in grasses, cyanogenic components, etc.).

5 Develop additional high-yielding legumes that are nonbloating.

7 Develop forage programs that will give farmers a profit in beef production that will allow U.S. beef to penetrate the world market.

Rank Order		
		8.1 Harvested Forages and Seed Production (continued)
8	SP	Devise alternative ways of harvesting, storing, and feeding harvested forages in order to maintain quality, reduce losses or waste, and improve efficiency.
8		Improve resistance of legumes to drought and salinity.
8		Develop methods for direct human utilization of alfalfa protein.
8		Develop bloat-safe or bloat-resistant species.
12		Develop breeding programs on a larger number of important forage species.
13	SP	Develop methods to fractionate herbage into commercial products other than forage itself, such as protein, chlorophyll, chemicals, drugs, etc.
13	SP	Develop integrated management programs for key pest species, including resistant varieties, pest population suppression (crop management, repellents, baits, etc.), use of beneficial insects, and improved pesticides.
15	SP	Develop a one-pass harvest system that eliminates the weather hazard, reduces labor, and maintains quality.
15	SP	Develop more effective breeding procedures (male sterility restoration, genetic markers, self-incompatibility, etc.) to improve biological efficiency and yield.
15	S	Develop methods of harvesting, processing, and preserving crop residues to be fed directly or to be chemically or physically modified to increase their quality for livestock feed.
18	SP	Develop economical animal management systems that include such alternatives as use of crop residues, semiconfinement, supplemental feeding, early calf weaning, bulk harvested and stored forages, and dormant standing forages.
18		Develop potentials of symbiotic nitrogen-fixation microorganisms associated with grasses and legumes.

Rank
Order

8.1 Harvested Forages and Seed Production (continued)

18 Develop new grass and legume varieties for mixtures and learn how to handle them nutritionally and in other ways to yield the greatest amount of high-quality feed.

18 Increase knowledge of needs for elements other than N, P, and K (such as S, Mg) and of optimum nutrient ratios.

S Investigate fundamental genetic and cytological phenomena that hinder plant improvement or that have potential use as breeding tools.

S Develop mechanical dewatering processes to reduce cost of dehydration; develop methods for using the removed "water" in liquid feeds, reconstituted grains, etc.

S Determine the factors that limit pollination in legume seed fields and the effects of pest control practices on bees and other beneficial insects.

S Develop improved approaches to timing of harvest, in order to increase persistence and productivity of grasses and legumes.

S Evaluate the potential of integrating forage livestock systems with disposal of effluent and solid wastes (agricultural and nonagricultural).

S Determine best formulation of forage supplement diets to meet specific livestock production targets.

S Improve methods to analyze and predict forage quality, so that forage products can be marketed according to established standards for use in least-cost, computer-formulated rations.

S Increase the biological availability of carbohydrate and protein in high-fiber feeds, using fermentation or other methods.

S Improve methods for conserving and increasing the biological activity of protein, carotene, and xanthophylls.

Rank Order		8.2 Permanent, Rotation, and Irrigated Pastures
1	SP	Collect, assess, and maintain germplasm of forage species for current and future use.
2	SP	Develop harvesting and grazing systems, using both annual and perennial forages, to achieve full-season utilization of forage and improve production per unit of area.
3	SP	Improve techniques for introducing improved perennial grasses and legumes into permanent sod, i.e., seed treatments, chemical renovation, sod seed equipment, fertilizer placement, etc.
4	SP	Develop grasses and legumes high in protein, digestibility, palatability, and intake potential.
4	SP	Determine the interaction of soil, water, and fertilizer, in order to establish best levels of fertilization to make best use of water.
4	SP	Develop rapid, accurate, laboratory procedures for predicting forage quality, intake, and digestibility.
7	SP	Develop grass and legume varieties capable of rapid recovery and high yield.
7		Develop livestock production systems with pasture (and forage) as a base and study the recycling of major nutrients such as nitrogen under sustained economical production commensurate with proper land use and minimal environmental insult.
9	SP	Develop basic data on animal utilization and response (forage intake, availability, digestibility, rumen residence time, rate of passage, etc.) in order to design better forage-animal systems.
10	SP	Match grasses and legumes, in combination with fertilizer and management, to maintain balance of grasses and legumes and to increase yield and quality.
11		Conduct studies concerning optimum integration of tame pastures and rangeland.

Rank Order		
		8.2 Permanent, Rotation, and Irrigated Pastures (continued)
12		Develop technology to maximize production of pasture from lands where erosion is a serious hazard.
12		Develop varieties and species of grasses and legumes that produce well in partially prepared (renovated) seedbeds.
14		Integrate all facets of research and practice dealing with pastures and livestock into systems that provide maximum return on investment.
15	SP	Develop grass and legume varieties that are compatible in forage mixtures.
15	SP	Determine the characteristics of major forages and forage mixtures (production patterns, response to grazing and harvesting, quality, etc.) in order to fit forages into specific animal production programs.
15	S	Develop standardized procedures for a nationwide inventory of forage resources.
18	S	Develop irrigation practices for various soil types, grassland regions; and types and sizes of forages to optimize efficiency of water use.
19	SP	Develop practices for economical production of livestock on pasture (stocking rates, grazing systems, combinations of livestock, overseeding or sod seeding, etc.).
19	SP	Improve methods of establishing temporary crops in permanent sod, i.e., mechanical and chemical treatments, plant nutrition, time and method of renovation, early seedling management, etc.
19		Develop recommendations for species, soil types, and management which will promote the most rapid recovery from the short-term concentration of livestock occurring because of calving, A.I. programs, etc.
	S	Provide information on the interaction of pastures and animals, including effects of forage use patterns on productivity of pastures and animals.
	S	Investigate soil-plant-animal relationships to improve animal production and forage quality and quantity.

Rank Order		
		8.2 Permanent, Rotation, and Irrigated Pastures (continued)
	S	Develop equipment for precision metering and placement of seed, fertilizer, and chemicals and for better vegetative propagation.
	S	Reevaluate pasture systems, using superior forages and animals.
	S	Determine the minimum rate of production for various classes and weights of animals that will provide animal products with quality acceptable to consumers and at a cost-price ratio profitable to producers.
		8.3 Range
1		Develop new approaches to minimize water loss on rangeland through water spreading, terracing, pitting, and other practices.
2	SP	Develop legume varieties adapted to grazing in semiarid areas.
3		Collect, evaluate, and exploit germplasm of species with potential use for improving rangelands.
4	SP	Develop varieties with more tolerance to such stresses as drought, temperature extremes, saline soils, alkaline and acid soils, and poor drainage.
5		Determine the what, when, where, and how of supplemental feeding related to range nutrition.
6		Develop knowledge concerning production, harvesting, and processing of seed of important range species.
7	SP	Develop efficient combination of treatments (grazing management, chemicals, mechanical treatments, controlled burning, etc.) to control brush and other weeds.
7	SP	Compare costs and benefits of the most promising systems of brush and weed control on grazing lands.
7	SP	Develop standardized procedures for a nationwide inventory of range resources.

Rank Order		
		8.3 Range (continued)
7		Evaluate the economics of range management systems including alternative uses for rangelands.
7		Develop safe, economical, and effective methods of brush and weed control.
12	SP	Integrate forage production and animal management systems to improve reproductive efficiency and the percentages of calves, lambs, and kids weaned.
12	SP	Develop improved shrubs, grasses, and forbs for semiarid rangelands.
12	S	Develop better knowledge of soil and microclimate factors affecting seed germination and seedling survival and vigor.
15	SP	Determine potential success of seeding for specific range sites and identify species and varieties adapted for use in them.
16		Determine cost and efficiency of development of livestock water supplies and their impact on surrounding rangeland.
17	SP	Evaluate the potential for forage production on all range areas and determine forage species suitable for various soil conditions.
17	SP	Select animal types particularly adapted to use rangeland forages.
17	SP	Learn how to modify existing management practices in order to slow or prevent the reinvasion of grazing lands by brush and other plants.
20	SP	Develop ways to more successfully establish seed species, including grasses, forbs, and browse species.
20	S	Develop and test remote sensing techniques for measuring vegetation, soil stability, site attributes, forage utilization, animal populations and movement, and major factors of range environment.
	S	Develop more effective strains of rhizobia and better ways to inoculate soils for specific legume varieties and soil conditions.

Rank
Order

8.3 Range (continued)

S Develop alternative grazing management systems combined with advanced range improvement methods.

S Develop methods to determine range forage intake and digestibility by grazing animals and associated digestibility values obtained in vitro.

S Evaluate rangeland seeding for livestock production, improvement of watersheds, and restoration of deteriorated ranges.

S Develop new approaches to (1) increase water intake of soils and (2) control evaporation and transpiration.

S Develop effective optimization models for determining alternative grazing ecosystem use.

9.1 BEEF

Objective: To produce the quality and quantity of beef required to help meet human food demands, with maximum efficiency in the use of land, animal, and feed resources, while maintaining environmental quality, reasonable profit margins, and retail prices that are compatible with consumer incomes.

SITUATION

The World

Included in this category is the meat from a variety of bovine animals descended from European and Asiatic races in large part but including African and American as well, and also buffalo, water buffalo, carabao, and bison. Some of these animals have specializations and adaptions which suit them to particular climates, forms of husbandry, and systems of agriculture, and may be well adapted to production of work and power. The genetic resources of this range of animals have not been fully developed, and rising fuel prices may focus attention on this situation as an opportunity for intensified developmental effort in some regions.

These animals produce both meat and milk which contain protein of exceptional value. The quality of protein is as important as quantity when considering the future world supply of food. These food products are good sources of B-vitamins and minerals. Meat also appears to contain factors that enhance the absorption of certain minerals.

Beef and milk take on added importance when we realize that a large portion of the current production is obtained by converting feedstuffs that cannot be used directly as human food. In the United States, forages currently make up more than two-thirds of all feed consumed during the lifetime of the beef animal, and it is possible to grow and finish cattle almost entirely on noncompetitive feedstuffs. Thus, the nutritional quality of beef and the relatively noncompetitive nature of its production has placed this product among the important world food sources.

World beef consumption reached 39 million tons in 1970. This represents an annual average consumption of 11 kilograms per person for the whole world. Beef consumption per person ranged from 79 kilograms in Argentina down to 0.3 kilograms in India, a country in which most people do not eat beef because of religious reasons.

In the developed countries it averages 20 kilograms; in the Central Plan regions, 8 kilograms; and in the developing countries, 4 kilograms per person.

Half of the world's beef (51 percent) is grown in the developing countries. The United States and the European Community produced more than 40 percent of the world's beef in 1970. Argentina, Central America, Mexico, Australia, and New Zealand exported 1.5 million metric tons of beef. These countries produced 12 percent and exported 3.8 percent of the world supply.

Beef production cycles in the United States and the European Community have been moving together for several years. Combined output was down in 1972 and 1973, but 1974 is expected to return to the 1970 levels, and 1975 should set a new record. World beef production reflects the irregularities generated by these cycles.

Herds are increasing in the countries that are the principal producers of commercial beef. In the United States, production patterns reflect the possibility of shifting between systems of grass and range grazing and intensive feeding of grain as the relative prices of these feeds change. In the European Community and other parts of Europe, less intensive grain feeding is typical, but beef production is very sensitive to policies designed for primary impact on the production of milk. In these regions, beef production is poised to rise firmly if weather and general economic conditions are favorable. In Argentina, Australia, Mexico, and Central America herds are large and growing.

Observed rates of growth for the various meats--when related to likely consistent scenarios of overall economic development, and trends of prices, incomes, and population around the world--permit projection of a 49 percent increase in 1985 beef and veal output as compared with 1970. This represents anticipated growth at an average compound rate of 2.7 percent per year, which is in line with developments in the 1950's and 1960's.

Beef entering international trade is expected to rise to about 5 percent of world beef output. Since world trade represents such a small portion of total production, developments in a few regions could bring changes to the entire pattern of world net trade balances.

Cattle and their meat may either be preferred or avoided by some of the religious systems of the world. Therefore, in some regions, cattle may not be acceptable as a subject for systematic research and economic development.

The United States

The beef cattle industry is an important segment of the agricultural economy of the United States and of most States. The number of beef cows on U.S. farms increased from about 26.3 million head in 1960 to 45.4 million head in 1975. During this same period, the number of all cattle and calves, other than those kept for milk, increased from about 66.1 million head to 116.5 million head.

As a result of increasing population, rising incomes, and changes in consumer taste, the demand for beef has been increasing. Beef enjoys a favorable position relative to other food items and even other meats. As incomes have risen, consumers have shown a preference for more beef from grain-fed animals as opposed to beef from forage-fed animals. To meet this growing demand, the production of grain-fed beef as a percentage of total beef has trended upward. Grain was a relatively cheap source of feed during this period, however, and the economics of the situation dictated grain feeding.

Many factors will determine the future direction of the U.S. cattle industry. The recent short supply and high price of feed grains has caused some decrease in grain-fed beef production. Future supplies and prices of feed grains will largely determine the future of grain-fed beef production. Public policy regarding feed grain production and exports will largely determine feed grain prices; and policies that lead to adequate supplies of feed grain at relatively low prices to the cattle feeder will favor grain-fed beef production. The economics of the situation will, moreover, determine the length of the feeding period. Policies that lead to short domestic supplies of feed grains at high prices will shorten the feeding period. In that case, a percentage of the beef cattle ration will be grasses and other roughages.

Although advancements in beef production technology have been adopted by many beef producers, there is still much room for improvement. A survey of persons with intimate knowledge of the cattleraising industry during summer 1971 indicate that they did not expect much advance by 1980 in increasing the calving percentage and number of calves weaned and in decreasing death losses. Productivity per cow could be improved by increasing the number of calves produced per cow per year; increasing the weaning weight of calves; use of improved grasses and fertilizers in pastures and ranges; better management and use of forages; improving animal health; and decreasing death losses. Progress is slow due to the slow adoption of new methods, lack of capital in some cases, and at times lack of profit incentives. Other possible areas for improvement are hormonal treatments for control of estrus and for

increasing fertility, use of bulls more accurately evaluated for probable breeding value, general use of crossbreeding systems, and changed or improved feeding practices.

The total units of feed required to produce a unit of gain is greater for beef cattle than for poultry and swine. Efficiency of the beef animal in this respect will likely improve as the nutritional needs of beef cattle are more accurately identified; as more is learned about factors affecting the efficiency of the conversion of feeds into metabolizable nutrients in the digestive tract; and as more efficient convertors of feed to meat are bred. It should be remembered, however, that the beef animal is a ruminant and has a distinct advantage over poultry and swine--it can utilize forages, cellulosic wastes, and nonprotein nitrogen. These feed materials are not in competition with human food supplies, and thus the beef animal is complementary rather than competitive in the production of protein. On the basis of pounds of concentrates consumed per pound of meat produced, beef cattle consumed less than swine and only slightly more than poultry. Improvements in the use of grains and other concentrates can lead to more efficient use of food-producing resources.

Increases in farm size and beef herd size will likely continue. This provides the environment for better management and the adoption of more technological innovations in production of both beef cattle and feed, particularly forages.

There has been a decline in the percentage of cattle going through terminal markets and an increase in direct marketing. The shift toward more efficient marketing of beef includes the shift to box beef and central cutting, which reduces transportation costs since significant amounts of fat and bone do not have to be transported--and in many cases can be utilized for higher value uses. Labor costs are also usually lower. In 1972, more than half the beef being shipped to supermarkets was centrally prefabricated. A shift to packer or centrally produced frozen beef cuts would produce further efficiencies but such a shift will largely depend on industry and consumer acceptance of this form of beef.

RESEARCH NEEDS

The following were identified as the important problems that require research related to beef.

Rank
Order

Production

1 SP Reduce effects of respiratory and enteric diseases, including shipping fever and calf scours.

Rank
Order

Production (continued)

Rank Order		
1	SP	Develop methods to increase production from range, silage, and pasture with new forages, fertilization, mechanical soil treatments, forage management, and livestock grazing management systems.
3	SP	Improve reproductive performance by identifying factors that (1) increase calf survival and (2) shorten the interval between calvings.
4	SP	Improve ways to use noncompetitive feeds such as crop residues, byproducts, etc., and to remove residues (animals as filters).
5	SP	Develop efficient ways to convert manure and other organic farm and processing wastes into usable byproducts; determine how much waste can go into the soil without affecting crop yield or quality of ground water.
6		Identify products and ways to use additives to increase animal production, including benefits, regulation, and safety.
7	SP	Prevent and control reproductive diseases including leptospirosis, vibriosis, and brucellosis.
7	SP	Improve reproductive performance through breeding systems, including crossbreeding.
7	SP	Determine the land, animal, human, and feed resources available now and potentially available in the future for beef production and consumption.
10	SP	Improve reproductive performance by developing techniques for estrus control and multiple calving.
11	SP	Prevent and control pinkeye, foot rot, anaplasmosis, etc.
12	SP	Develop methods to more accurately forecast economic trends and social impact, including cycles in feed and beef supplies and prices.
13	S	Develop methods to better determine the source, chain of transmission, and detection of intentional and unintentional potentially harmful residues in products and rapid methods of clearance from animal systems.

Rank Order		
		Production (continued)
14		Develop a statistical data base on disease incidence and the geographical distribution of diseases as an aid in identifying the influence of environmental factors on animal health.
14		Improve methods for feed production with minimum concentrates.
18		Determine cost risk-benefit aspects of regulations.
	S	Prevent foot-and-mouth disease and other foreign animal diseases.
	S	Prevent and control internal and external parasites.
	S	Continuously evaluate foreign market potentials for beef and live cattle and the impact of imports.
		Marketing and Processing
14	SP	Improve methods of converting the live animal to edible and inedible products.
18	SP	Improve marketing procedures, including slaughter and processing, storage, merchandizing, and maintenance of nutritional and eating qualities.
18		Develop processing and distribution methods that conserve energy without adverse effect on quality.
		Consumer Needs and the Environment
14		Develop basic knowledge and expertise in meat microbiology as related to quality and safety.
18		Determine consumer attitudes on the quality of beef and beef products.
	S	Develop control methods for livestock insect pests that minimize environmental contamination.

9.2 PORK

Objective: To produce the quantity and quality of pork required to help meet human food needs, with maximum efficiency in the use of land, animal, and feed resources, while maintaining environmental quality, reasonable profit margins, and retail proices that are compatible with consumer incomes.

SITUATION

The World

World consumption of pork was 34 million metric tons in 1970, and pork constituted one-third of all meat consumed, including poultry. Per capita pork consumption averaged 10 kilograms for the whole world. It averaged 23 kilograms in developed countries, 13 kilograms in Central Plan countries, and only 1.6 kilograms in less developed regions.

Nearly half of the world's pork (47 percent) is produced in the developed countries. Somewhat less (45 percent) is raised in Central Plan countries, and 8 percent is raised in the developing countries, which have nearly half the world population. Mainland China accounts for 26 percent, the European Community for 20 percent, and the United States for 18 percent of world output.

International trade in pork is largely local and border-balancing. The principal flow is U.S. importation from Europe (East and West) which amounts to less than 2 percent of U.S. consumption and is a negligible proportion of world production.

Pork cycles are of shorter duration than beef production cycles and have a more random effect on world meat production. However, from time to time they generate production declines that accentuate the effects of the declines in beef production. In 1972 and 1973, this happened in both Europe and the United States. Production increased in 1974, but prospects for 1975 are uncertain because of the high input cost of grain and other feeds.

Observed rates of growth for the various meats related to overall economic development and trends of prices, incomes, and population around the world permit projection of a 51 percent increase in 1985 pork output as compared with 1970. This represents anticipated growth at an average compound rate of 2.8 percent per year, which is in line with developments in the 1950's and 1960's.

Pork production practices vary greatly from place to place around the world. Generally, it tends to be a scavenger type of operation in low-income regions and uses more grain and commercial feeds according to the scale of affluence. In scavenger operations, swine are potential carriers of human as well as animal diseases. Heavy inputs of grain per unit of pork obtained are characteristics of the United States and Western Europe. However, some systems of pork production have been observed in Western Europe that do not use grain at all; all feed is derived from forage.

Swine and their meats may be either preferred or avoided by some of the religious systems of the world. Therefore, in some regions, swine may not be acceptable as a subject of systematic research and economic development.

The United States

U.S. pork production has not increased appreciably during the past two decades. It has, however, exhibited cyclical changes with the number of hogs and pigs on farms varying from about 50 million head to a little more than 65 million head. U.S. pork production is centered in the Corn Belt. Some geographic change is occurring; for example, there is a continuing east-to-west shift of production within the Corn Belt and a steady growth of pork production in the Plains States and Southwest. Although these geographic changes are likely to continue, shifts away from the chief areas of feed grain production seem most unlikely in the foreseeable future.

Major changes have occurred in swine production practices in the United States over the past 25 years. Increased and more efficient production generally has resulted from these changes, but important problems remain and new ones have arisen. Some of the more recent of these changes are the splitting of the enterprise between production of feeder pigs and finishing; increased effort toward large totally integrated units; and shifts from the pasture-oriented to the confinement systems. Some of these changes have created new problems in reproductive performance, waste handling, and other fields of management.

Reproductive efficiency in swine has shown only marginal improvement over the past 25 years. Litter size has not increased appreciably and baby pig losses remain generally high. Efforts to increase the number of pigs saved per litter from the average of near 7 in recent years have not been very effective. Also, increasing the number of litters produced per sow per year has met with only marginal success. Techniques for preserving boar semen and for the artificial insemination of swine have advanced greatly in recent years, but high costs and ineffective synchronization of heat periods in sows have largely

limited the application of artificial insemination. Sizeable increases in the quantity of pork produced per sow could be realized if the number of pigs produced per sow per year could be increased. This will require improvements in the genetic quality of swine, better understanding of reproduction physiology, improved rations, improved disease control, and better management.

The trend has been to produce a meat-type hog with less fat. The average weight of barrows and gilts produced has been in the 230 to 237 pound range for several years. The pounds of lard produced per 100 pounds of meat has trended downward, however, from 13.5 pounds in 1960 to 6.8 pounds in 1973. There are indications that, coinciding with this downward trend, the incidence of stress-related problems has increased.

Swine producers encounter waste management problems at the site of production in the utilization or disposal of the manure. Investments and annual costs for waste management are larger for confined production systems than for pasture systems. More confinement operations and probable future environmental quality regulations will create additional problems in waste management.

Not much advancement in the feeding efficiency of hogs has been made in the past several years. It is quite probable, however, that the pounds of feed required to produce a pound of pork can be reduced as management systems are improved, as rations are improved, and as breeders develop more productive animals. Greater feed efficiency has been achieved in some of the large-scale intensive production systems, and the movement toward this type of system may help to improve overall feed efficiency in the pork industry.

Changes also have been made in the marketing of swine and pork. More hogs are now being marketed directly rather than moving through terminal markets. More hogs are also being marketed on a grade and yield basis. Further changes to reduce the overall cost and present a more acceptable product are also expected in the future.

RESEARCH NEEDS

The following were identified as the important problems that require research related to pork.

Rank
Order

Production

1 SP Increase the pig crop by such means as lower mortality of unborn and newly born animals, control of estrus and ovulation, and through possibilities of very early weaning and life cycle nutrition.

Rank Order		
		Production (continued)
2	SP	Develop improved methods to prevent and control swine diseases: arthritis, atrophic rhinitis, bloody dysentery, TGE, TB, etc.
3	SP	Identify and develop breeding systems that maximize efficient production of quality pork with consumer acceptability, including consideration of important traits (reproductive efficiency, gain, feed efficiency, muscling, quality, etc.) and specific adaptability to given environments.
4	SP	Develop more effective technology to reduce the incidence of enteric, reproductive, and respiratory diseases.
5		Develop methods to better determine the source, chain of transmission, and detection of intentional and unintentional residues in products and rapid methods of clearance from the animal system.
9	SP	Develop housing and waste disposal or handling procedures that not only are efficient but also protect environmental quality.
9	SP	Determine the effects of environment, housing, management, and equipment on feed conversion and total productivity including regional variation.
11	SP	Investigate ways to reduce or eliminate pork stress syndrome (PSS) and pale, soft, exudative pork (PSE).
11	SP	Improve the diagnosis, prevention, and control of foreign animal diseases that threaten the U.S. swine population (African swine fever, swine vesicular disease, foot-and-mouth disease, etc.).
11	SP	Develop energy conservation procedures in all phases of swine production and processing.
15		Determine minimum grain usage feeding programs and economic impact studies and consumer acceptability of product produced.
15		Develop improved feeding and management of the sow and her litter, especially in confinement.

Rank
Order

Production (continued)

17 Develop and evaluate alternate sources of feed, seeking methods of production which reduce the use of concentrates.

18 Conduct research to develop a more complete understanding of the disease defense mechanism in the pig as related to housing, management, and production systems.

20 Develop baby pig rations and handling systems for weaning at or near birth.

S Determine the influence of nutrients on hormones affecting reproduction and carcass composition.

Marketing and Processing

5 SP Improve slaughter systems and evaluate hot processing of pork and other rapid processing systems, centralized packaging of fresh pork, and the market for new pork products.

11 Conduct studies to improve methods of handling, transportation, and marketing to reduce shrinkage and shipping losses and protect against stress and animal disease.

19 SP Evaluate the need for a system of grade and yield pricing along with a possible retail marketing system that would be equitable to producers, processors, and consumers.

S Develop international standards on diseases of live animals and quality identification standards for U.S. products to meet foreign market requirements.

S Identify other countries that are potential customers for pork products and develop the technology needed to export safe, high-quality pork and pork products.

S Evaluate the need for better market communication systems.

Consumer Needs

5 Study possible replacement(s) for the use of nitrite in pork processing.

Rank Order	
	Consumer Needs (continued
8	Develop greater knowledge and expertise in meat microbiology related to quality and safety.
S	Develop meaningful consumer preference information and quality standards for pork to help the consumer in selecting wholesome, flavorful, and safe pork.

9.3 LAMB AND MUTTON

Objective: To produce the quality and quantity of sheep meat required to help meet human food demands, with maximum efficiency in the use of land, animal, and feed resources, while maintaining environmental quality, reasonable profit margins, and retail prices that are compatible with consumer incomes.

SITUATION

The World

In 1972, the peoples of the world consumed about 109 million metric tons of meat (FAO data). Of this total, about 6 percent was from sheep and goats; 44 percent was from all ruminants.

The number of ruminants and ruminant meat production rose in the past decade, but much of the increase can be attributed to feeding of inexpensive grains. However, shifts to the production of ruminant meat largely from feeds other than grain will give an advantage to the sheep and goat relative to beef cattle. Because of the high efficiency of sheep in converting forages, crop residues, and wastes to high-quality meat, there is likely to be a worldwide trend toward increased production and consumption of sheep meat.

Sheep can be productive under very rigorous conditions, and they give milk as well as meat and wool. They can produce quality meat under environmental conditions unsuitable for cattle, hogs, and poultry, but intensive feeding is practiced in favorable areas. An array of cheese and dairy products is obtained from their milk.

Sheep meat is the most uniformly distributed of the basic types of meat. It is acceptable where there are religious and cultural injunctions against beef and pork.

In the past decade, the production of sheep and goat meat rose from 4.7 to 4.8 kilograms per animal, but production per person fell from 2 to 1.9 kilograms.

Worldwide consumption of sheep meat is less than 2 kilograms per capita. Per capita consumption is 3.4 kilograms in developed countries, 1.6 kilograms in Central Plan countries, and 1.4 kilograms in developing countries.

Observed rates of growth for the various meats related to likely overall economic development and trends of prices, incomes, and population permit projection of a 49 percent increase in 1985 mutton production as compared with 1970. This represents anticipated growth at an average compound rate of 2.7 percent per year, which is in line with developments in the 1950's and 1960's. International trade in mutton is expected to continue at about 10 percent of world mutton production but at less than one percent of world meat production.

The United States

The United States is among the world leaders in efficiency of lamb meat production. Over the past decade, the increase in lamb meat per sheep rose 10.7 to 12.2 kilograms compared with an increase of from 9.4 to 11.1 kilograms for Ireland. The U.S. gain was made despite a high increase in loss to predators--to an estimated equivalent of about 2 kilograms of meat per sheep.

Technology is now available for a much more rapid increase in efficiency in the next decade through: More intensive use of selection to increase lambing rates, rate of gain, and feed efficiency. A new continuous, multibreed system of crossbreeding to increase lambing rates and to decrease mortality. Use of the Finnsheep breed to increase lambing rates. Artificial rearing of lambs to reduce mortality. Multiple lambing, year-round lambing, and pregnancy diagnosis to increase lambs per ewe per year. More effective predator control to remove the main barrier to lamb meat production. Better management, nutrition, and disease and parasite control to increase lamb survival and market weights.

Decline of the sheep industry in the past decade can be explained largely by loss of sheep farms and exceptionally high losses to predators. While the loss of sheep farms has amounted to only 4 to 9 percent per year, the losses have been continuous and have accelerated over a period of 10 to 15 years. The declining number of sheep has increased marketing difficulties, and this has resulted in a much wider spread between live lamb and retail prices than in the case for beef or pork and a related increase in the relative value of cattle to sheep. There has been a marked shifting from sheep to beef cattle because of relatively higher incomes from beef and lower vulnerability of cattle to predators. However, the relative value of cattle to sheep has dropped more radically this past year than at any time since the Civil War. This, along with continued high grain prices, could lead to a rapid increase in sheep production and in the availability of lamb meat for export.

Forages suitable for ruminants can be produced on vast areas of land in the United States that are not suitable for cultivation. There are opportunities to increase this forage production and to use it more fully. There are also quantities of crop residues and wastes that can be utilized best by ruminants. Sheep, because of their adaptability to extremely rigorous conditions, are well suited to use these feed materials to produce meat, fiber, milk, cheese, and hides. Wool production is an important part of profitable sheep production, and it becomes more attractive during periods of petroleum shortages because the manufacture of synthetic fibers requires petroleum both as a basic ingredient and as an energy source.

RESEARCH NEEDS

The following were identified as the important problems that require research related to lamb and mutton.

Rank
Order

Production

1 SP Develop methods of reducing predator losses under a wide variety of range and farm conditions.

2 SP Increase lambs per ewe per year by such means as selection, crossbreeding, and the use of hormones.

3 Determine the causes and prevention of pneumonia in feedlot lambs and breeding ewes.

4 SP Prevent or reduce losses from diseases, parasites, poisonous plants, contaminants, and other toxic substances at all stages of production, processing, and marketing.

5 Conduct research to reduce labor costs and/or change practices to make labor in sheep production more attractive.

7 SP Develop total management system for breeding, reproduction, artificial insemination, nutrition, and management under various resource conditions.

8 Develop methods to better determine the source, chain of transmission, and detection of intentional and unintentional potentially harmful residues in products and rapid methods of clearance from the animal system.

8 Conduct research on shipping fever including information on the genetic, nutritional health, and management background of animals as well as shipping and postshipping conditions.

Rank Order		
		Production (continued)
11	SP	Reduce losses from reproductive diseases.
11	SP	Increase efficiency of feed use and productivity to produce a marketable product by such means as selection and cross-breeding.
11		Develop supporting data for the use of selenium in sheep feed.
11		Determine the effect of genetics on resistance and susceptibility to specific diseases.
18		Develop new approved additives for promoting health and production.
20	SP	Develop low-cost treatments to make the nutrients in high fiber and cellulosic feeds more available.
	S	Determine nutrient requirements for all phases of sheep growth, maintenance, and reproduction.
		Consumer Needs
6	SP	Develop new products from lamb and mutton to improve consumer acceptance.
8		Develop efficient methods for the increased utilization of carcasses and byproducts of slaughter including both edible and inedible tissues for human use.
		Marketing and Processing
11	SP	Develop ways to cut and package so that (1) lamb and mutton products will not require further processing after the slaughtering plant and (2) shelflife will be increased.
11		Determine the sources of and the prevention of salmonella infection in transported feedlot lambs.
17	SP	Develop lamb grading standards that are meaningful to consumers, producers, processors, and distributors.
18	SP	Develop information on market potential for lamb or wool.

9.4 OTHER ANIMAL PRODUCTS

Objective: To fully utilize food producing capabilities of other animals, such as rabbits and goats, and to maximize their productivity consistent with environmental quality and alternate uses of resources.

SITUATION

"Other animal products" include foods from all wild and semidomestic game, such as:

- Meat of deer, antelope, caribou, elk, and other large game.

- Meat of furbearing animals, such as rabbit and hare, including that of highly developed meat-producing varieties of domestic animals that are used in Europe in considerable abundance.

- Exotic wild meats of animals hunted for sport and kept for private trophy and eating. (Hunting parks for birds and game animals are on a rising trend.)

- Meat of asses and mules, which is rejected by U.S.--but not by universal--custom.

- Horsemeat and mare's milk.

No attempt is made here to provide a quantitative breakdown of this category. However, even this partial listing suggests that in this category there are important areas for research and development aimed at conserving and gaining access to new genetic resources.

The predominant animals in this category in the United States are rabbits and goats. Therefore, the remainder of this section deals only with these two.

Rabbits--Domestic rabbit production in the United States has declined considerably over the past 20 years because meat from other sources (particularly beef, pork, and poultry fed surplus grains) was available at relatively low prices. However, rabbit meat production can be expected to rise in depression periods and in times of food shortages because rabbits can be produced under backyard conditions at least partily on low-cost, noncompetitive feeds. They offer an opportunity for people to produce more of their own food and a source of supplementary income if market outlets are available.

The domestic rabbit compares favorably with other meat-producing animals and poultry in its conversion of feed crops to meat for human consumption. It lends itself as a source of supplemental income since the care of rabbits may be organized within a 5-day week or a part-time schedule and the work is not arduous. Rabbits can be raised easily in suburban areas if regulations permit. They are particularly suited to areas of rural poverty because of their production of high-quality protein at low cost. For this reason, they may be particularly useful in developing countries. There may be possibilities for this infant industry to develop into a major food industry.

The total commercial processing of rabbits for meat in the United States is estimated at about 4 million fryers annually. In addition there are from 50 thousand to 100 thousand hobby producers and fanciers who produce another 4 million to 8 million fryers. Thus, there would be a total production of about 8 million to 12 million fryers with an estimated return to producers of $15 million annually.

Rabbit production is important in the support of medical research and other basic research in the life sciences. The number of animals of the quality needed is below potential demands for medical research and teaching. The demand for biological materials from rabbits appears to be expanding continually.

With current technology, domestic rabbits can probably produce meat at competitive or possibly lower costs than can alternative meat sources in all parts of the world.

Goats*--Goats have provided milk products, meat, and fiber for centuries. There were as estimated 396 million goats in the world in 1972. Goats tend to be a more important source of food and are more numerous in developing and less affluent countries. In the United States, there are three distinct types: Angora goats, which are primarily raised for fiber production; "Spanish" or meat-type goats, produced for meat; and dairy goats, maintained primarily for milk. Males and cull female Angora and dairy goats are salvaged for meat.

Angora and "Spanish" goats are raised under extensive-type production systems on the brushy ranges of the Southwestern United States; the major concentration is in the Edwards Plateau region of Texas. They are particularly well adapted to this area because they use large amounts of available browse. Therefore, they are not in direct competition with cattle and sheep for grass and allow a means for more efficient use of total range resources. Many ranchers in the

*Private correspondence with Carl Menzies, February 26, 1975.

area run a combination of cattle, with sheep and/or goats. In addition to the increased income and production of animal products obtained by grazing goats with cattle and/or sheep, goats also help to control brush infestation of ranges.

The only available goat inventory in the United States is that for Angora goats in Texas, which were reported at 1,150,000 on January 1, 1975. Texas normally produces 96 percent of the United States mohair. Angora goat production has been important in Texas since 1849. Castrated males are maintained for hair production until around 3 years of age or until hair production and quality decline. Cull females and males and castrated males are salvaged for meat, which is used chiefly in processed products. Some live goats and goat meat are exported to Mexico.

Although precise statistics are not available, the number of "Spanish" goats in the Southwestern United States is large and appears to be increasing rapidly. The "Spanish" goat is not a breed, but it is distinct from Angoras and dairy goats. They probably trace back to goats introduced by early Spanish explorers and have since received some infusion of both dairy and Angora breeding. They are multicolored animals usually produced under extensive range systems. They are prolific (high incidence of twin births) and hardy animals that normally receive limited care and supplemental feed. Kids are slaughtered for meat at a young age. The meat, known as "cabrito", is consumed mainly in the local area and California. It has good consumer acceptance. Cull mature animals are salvaged and enter the same trade channels as meat from Angoras.

Goats produce milk with high efficiency and tend to be important where people produce their own food. In the United States, most goats are raised in small herds and are used mainly for milk for family use. Goat milk is often produced near large cities for use by people who are allergic to cow milk and especially for infants and invalids. The average dairy goat produces almost 500 kilograms of milk per year and is said to produce milk more efficiently and at lower feed costs than dairy cows.

Markets for goat meat and milk products are limited and not highly developed. Quality grades for goat meat have not been standardized. Considerable research has been conducted in the United States on Angora goat production for mohair. But research directly related to the dairy and "Spanish" goat industries has been very limited. The technology used for production of these types of goats has been developed from producer experience or derived from research on other animals.

Goats undoubtedly have potential for making greater contributions to the world food supply. They appear to be efficient in converting feed resources into food and fiber and can use many range resources that cannot be used by cattle. This neglected domestic animal should benefit from technology developed from new research programs that focus on reproduction, genetic selection, management, and product evaluation, development, and marketing.

RESEARCH NEEDS

The following were identified as the important problems that require research related to other animal products.

Rank Order		Production
1	SP	Improve methods to prevent or control diseases of goats, particularly respiratory diseases, enteritis, mastitis, and those directly affecting reproduction.
2		Develop effective predator control practices for range goat production.
3	SP	Develop better methods to prevent and control rabbit diseases, particularly enteritis and respiratory diseases.
4		Determine nutritional requirements for goats in different stages of the production cycle for both meat and milk production and develop table rations for milk production and table supplements for goats on ranges.
5	SP	Investigate genetic parameters concerned with reproduction, rate of growth, milk production, and carcass traits of meat-type goats in the United States and the world; develop selection procedures to effectively improve important production traits.
6	SP	Reduce death losses, especially of young rabbits.
8	SP	Develop management practices to intensify production of meat-type goats under varying climatic conditions.
8		Search for new forage materials for rabbits in the United States and the developing countries.
10	SP	Develop semen preservation and efficient artificial insemination techniques for goats.

Rank Order		
		<u>Production</u> (continued)
10		Develop ways to reduce feed waste.
10		Determine the nutrient requirement for rabbits.
15	SP	Evaluate the potential of goats for biological control of brush and noxious plants in different areas of the United States.
17	SP	Develop a sire evaluation program for goats similar to that used for dairy cattle.
17		Study the effect of environment on the reproduction rate of the doe.
19	SP	Overcome seasonal breeding habits of goats.
	S	Develop procedures to select important productivity traits in goats.
	S	Develop ways to use low-cost and noncompetitive feeds.
	S	Evaluate the comparative efficiency of meat production by meat-type and dairy goats.
	S	Develop better management to increase efficiency of meat and milk production by goats.
		<u>Marketing and Processing</u>
6		Determine the probable market demand for rabbit meat in the United States and the export market at present prices as well as at those prices that would result from substantial reduction of feed cost.
10		Improve meat processing efficiency, develop a grading system for uniform evaluation of meat products.
10		Determine the feasibility of balancing diets in developing countries by raising rabbits as a source of high-quality protein.
16		Identify other countries that are potential customers for goats and goat products and develop technology needed to export safe, high-quality products.

Rank Order	
	Marketing and Processing (continued)
19	Develop and evaluate market potentials for goat meat and milk.

10.1 DAIRY

Objective: To produce the quality and quantity of milk and milk products required to help meet human demands, with maximum efficiency in the use of land, animal, and feed resources, while maintaining environmental quality and a reasonable return on investment so as to reduce the real cost of milk and its byproducts to the consumer.

SITUATION

The World

The distribution of dairy products is almost worldwide, and the high-quality, well-balanced nutritive content of milk, which is especially beneficial to the young, is generally known. However, as with all products from domesticated animals, high per capita levels of production and consumption are concentrated in the developed countries. About two-thirds of the milk cows are in the developing countries, but yield per cow is, in general, very low compared to yields in the developed world. Consequently, about one-third of the dairy cows in the world, located in the United States, Canada, Japan, Oceania, Europe, and the U.S.S.R., produce about 80 percent of the milk.

From the point of view of meeting world food needs, it is useful to categorize technology in the dairy industry into laborsaving technology and output-increasing technology. The major dairy areas have, for the most part, adopted output-increasing technology, primarily better feeding, breeding, management, and veterinary practices. Laborsaving technology has been adopted to varying degrees, depending on the socioeconomic structures and the relative availability of capital, labor, and machinery.

Neither type of technology has been adopted by the developing world. Laborsaving technology would, in general, not be very economical in much of the developing world, since human labor is much more plentiful, and there is a significant difference in the cost of capital and labor. However, developing or adopting known output-increasing technology would be vital to any decision to further develop dairy farming in these areas.

One other point relevant to decisions to pursue livestock production in the developing countries is that dairy farming produces both milk and beef, and therefore total output per acre is potentially higher for dairy farming as opposed to specialized beef production.

Viewed in the context of the energy-intensive agriculture of developed countries, the prospect of dairy farming playing an important role in meeting world food needs would not be bright. However, ruminants provide a means for converting materials unsuitable for human consumption into human food and other usable byproducts. Forages are coarse, bulky, and fibrous, and cannot be used directly by man. The forage-ruminant combination is a natural and effective way to use world forage resources to the benefit of mankind. Among the ruminants, the dairy cow is particularly efficient in transforming dietary nitrogen and energy into an edible product--milk.

The dairy cow also is an efficient user of foodprocessing byproducts such as bran and other milling byproducts, oil seed cake, and pulp from fruit and vegetables. In many developing nations, milk can be one of the most dependable sources of protein, calcium, riboflavin, and other minerals and vitamins available to the rural farm population.

Most developed countries have had a price support and stabilization program for dairy products since World War II. Under these programs, temporary surpluses of dairy products have accumulated, causing some repercussions in international trade due to subsidized exports. However, in the longer run, price supports have approximated market-clearing levels. Milk is considered a highly essential food in most developed countries, and without a price support stabilization program, prices of milk to consumers would be highly variable due to variable production (especially seasonal) and a highly inelastic market. Consequently, the dairy industry, perhaps more than any other food industry, is intricately woven into the sociopolitical fiber of most developed countries.

The United States

The dairy industry in the United States is an important element in our total agricultural sector. Consumer expenditures for milk and dairy products were $19 billion in 1973. Dairy products make up about 16 percent of at-home expenditures for food. Some 385 thousand farms reported having milk cows in 1973. Dairying is also important to the industrial sector, since dairy processing plants employ about 200 thousand people.

Dramatic changes have occurred in the dairy industry in recent years. Typical production units are rapidly becoming fewer, larger, and more specialized. The number of farms reporting dairy cows has fallen from 1,986,000 in 1959 to 384,000 in 1973. Most noticeable is the rapid disappearance of small herds of from 1 to 19 cows. Dairy farmers with 30 or more cows are producing an increasing share of the total milk produced.

Economies of size, new technology, expansion to improve incomes, and large capital investment requirements are among the complex set of social and economic forces causing these changes. Many of these forces still exist and will likely continue the trend to fewer and larger farms. A different view, however, is that the energy crisis, environmental constraints, and declining employment opportunities (rising unemployment) during 1974 and early 1975 may alter these trends for the near future.

Labor productivity in U.S. dairy farming has more than doubled since the early 1960's. Although due, in part, to less efficient farms going out of business, productivity has also been raised by substantial inputs of capital and energy as well as increased milk production per cow. Through improved breeding, feeding, and management, milk output per cow has increased from 4,800 to 10,125 pounds from 1945 to 1973, while the number of cows declined from 25 million to 11 million during the same period. Much of this increased productivity was related to increased feeding of cereal grains and other concentrate feeds.

Participation in herd record programs and genetic improvement have been important factors. At the beginning of 1974, about 3.5 million milk cows were enrolled in the National Dairy Herd Improvement program (DHI) and other testing programs. This represented about 31 percent of the total U.S. dairy herd, compared with some 17 percent a decade earlier. In 1973, milk cows under DHI programs averaged 13,287 pounds of milk, well above the 10,125-pound national average.

Total milk production rose to 125 billion pounds in the early 1960's and then fell to about 118 billion pounds in the late 1960's and early 1970's. Total production continued to decline, and in 1975 it is about 115 billion pounds.

Recent projections indicate that although milk production is expected to increase to about 119 billion pounds by 1980, an estimated 47 percent (about 180,000 herds) of the U.S. dairy herds will discontinue production. Thus, by 1980, about 200,000 dairy farms will be producing the domestic supply of milk. The number of herds of 100 or more cows is expected to continue to increase and to produce a higher proportion of the milk supply.

Government participation in fluid pricing arrangements began in the 1930's. Today, about 60 percent of all milk sold to plants and dealers, and about 80 percent of the fluid grade deliveries in the Nation, are regulated by Federal milk orders. Also, 18 States now have laws authorizing regulation of milk prices. In total, more than 95 percent of milk meeting sanitary standards for fluid use is priced under Federal or State orders.

The dairy price support program supports the national average prices received by farmers for manufacturing milk. The price support is accomplished by a government offer to purchase butter, Cheddar chesse, and nonfat dry milk at price levels intended to attain the announced floor on prices for milk of manufacturing grade.

The dairy processing industry, like dairy farming, has undergone dramatic changes. In the past two decades, there has been a rapid decline in the number of plants producing every dairy product except Italian cheese. Meanwhile, output per plant is trending upward. For example, in 1972, 7 percent of the butter plants each produced 8 million pounds or more of butter, accounting for 50 percent of the total output. In the same year, 11 American cheese plants, or 2 percent of the total, each made more than 20 million pounds of cheese, accounting for 21 percent of the total output.

In the fluid sector, as in the manufacturing sector, the trend has been towards fewer and larger processing plants. The number of fluid milk plants in the United States has declined by more than 75 percent during the past 25 years, and there are less than 2,000 such plants today.

Supermarket chains have become increasingly important in the distribution of fluid milk. During the past decade, a growing number of chains have started to process and package their own milk. Regional dairy cooperatives have become increasingly important in the procurement of milk. Consolidation and merger of cooperatives has greatly increased their influence in the marketplace. Their role in procuring, assembling, and coordinating a fluctuating milk supply has increased, and the regional cooperatives have consolidated manufacturing facilities--especially cheese plants. The importance of large national and regional proprietary firms in processing and distributing has, in turn, declined. The large dairy companies have diversified over the years, entering a wider and wider variety of nondairy product lines.

Per capita consumption of dairy products, on a milk equivalent basis, declined steadily from 653 pounds in 1960 to 561 pounds in 1970, and then leveled off at about 558 pounds in 1973. Estimates for 1974 show a further decline to a per capita consumption of about 543 pounds milk equivalent.

Shifts have occurred in per capita consumption among principal dairy products. Substantial decreases in consumption of butter, cream, whole milk, and canned milk occurred between 1960 and 1974. During the same period, the per capita consumption of low-fat and skim milk and cheese increased substantially. Per capita use of milk in frozen dairy products has remained fairly constant since 1960. The nonfat

solids content of milk and dairy products per capita remained fairly constant between 1960 and 1974, while the fat content decreased by about 20 percent.

Today, essentially all the skim component of milk is being used for human food. It is apparent that further increases in the use of skim milk (nonfat component) cannot occur without an increase in milk production. The value of farm milk has already shifted to the nonfat component so much so that butter prices now compete reasonably well with those of margarine. Low-fat dairy products are expected to increase in price relative to high-fat products as a result of the change in value of milk components.

RESEARCH NEEDS

The following were identified as the important problems that require research related to dairy.

Rank
<u>Order</u>

<u>Production</u>

1 SP Improve methods for identifying superior dairy animals, specifically bulls and brood cows, including animals with high genetic potential at an early age.

4 Determine incidence and distribution of disease problems on a continuing basis, thereby detecting high priority disorders and evaluating health care systems initiated for their control.

5 SP Develop feeding systems to achieve optimum milk production in relation to costs.

7 SP Develop systems to increase voluntary intake of forages and digestibility of forages, crop residues, cereals, various processing byproducts, and nonprotein nitrogen.

9 SP Develop more efficient ways to convert farm and processing wastes into usable products; determine how much waste can go into the soil without affecting crop yield or quality or ground water.

11 Reevaluate the price support systems now being used in the milk industry. The 1930's price system does not work for the 1970's.

Rank Order		
		Production (continued)
13	SP	Develop better methods to prevent and control reproductive diseases such as vibrosis, leptospirosis, and brucellosis.
13	SP	Determine the nutrient requirements of high-producing dairy cows, including extending their productive life.
15		Determine the interrelationships between and among physiological, genetic, housing, nutritional, disease, and management factors for delineating total systems which optimize milk production efficiency.
16		Develop improved rations for heifers and determine the effect they have on the ability of the animal to produce at maturity.
17	SP	Develop methods to identify breeding animals that will perform efficiently on high-forage diets.
19		Determine the indicators of innate disease resistance and select for such resistance.
20		Develop better immunization and management methods to prevent and control calf scours and other enteric diseases.
	S	Develop better ways to prevent, treat, and control mastitis.
	S	Develop better ways to prevent toxicosis and toxic residues in dairy products and meat.
	S	Improve calf and young stock management systems for development of replacement animals.
	S	Increase efforts to prevent and control foot-and-mouth disease and other foreign animal diseases that threaten U.S. cattle populations.
		Marketing and Processing
8		Develop more data and information on the handling of wastes, especially information on the biodegradability of animal fat versus petroleum-based oils. This should include methods of distinguishing between animal fat and petroleum-based oils and methods of monitoring the quantities placed in municipal sewage systems.

Rank Order		
		Marketing and Processing (continued)
10	SP	Improve economic and physical efficiency in various phases of assembly, processing, distributing, merchandizing, and pricing of milk and dairy products.
11		Evaluate the alternative sources of energy to be used in milk processing, manufacturing, packaging, and distribution. This should include availability of alternative sources, ecological impact of alternatives, engineering aspects, and economic consequences.
18		Develop methods to better market dairy beef, particularly dairy cows in good condition.
	S	Improve methods to reduce spoilage or quality loss in dairy products.
	S	Improve methods, including packaging and storage methods, for cheese and certain other dairy products in order to meet international competition.
		Consumer Needs and the Environment
1		Develop more uses for components and nutrients of milk in beverage products and other food products. Whey probably offers the most immediate opportunity and the greatest payback and could be a major factor in improving nutrition.
1		Resolve controversial questions about the nutritional value and safety of calcium, lactose, cholesterol, fats, fatty acids, and other milk components when humans consume dairy products in a normal dietary pattern.
5		Develop workable guidelines to evaluate the significance of minute residues of chemical substances in milk and meat.
	S	Develop reliable, rapid, and practical ways to detect undesirable residues and evaluate their significance to health.
	S	Develop background facts for coordinating environmental activities and developing standards designed to minimize economic impact on the industry.
	S	Develop a wider selection of dairy products to meet special dietary needs, such as low-sodium milk, low-lactose milk and milk products, low-calorie frozen desserts, and low-cholesterol and low-fat products.

10.2 POULTRY

Objective: To achieve the highest production and marketing efficiency of highest quality poultry and eggs consistent with the best use of resources.

SITUATION

The World

World poultry consumption reached 16 million metric tons in 1970, which is 15 percent of world meat consumption and represents an average rate of consumption of 4.4 kilograms per person. In the developed countries, per capita consumption reached 12.8 kilograms compared with 4.1 kilograms in the Central Plan countries and 1.2 kilograms in the developing regions.

More than half (57 percent) of world poultry was produced in the developed regions. Nearly a third (30 percent) was from the Central Plan countries. One-eighth was produced by the less developed countries.

World poultry trade consists of short-run flows, is very price and cost sensitive, and is largely offsetting, with small net effects. The developed countries export about 2 percent of their output--about 1 percent of world production.

Observed rates of growth for the various meats--when related to overall economic growth and development--and trends of prices, incomes, and population around the world permit projection of an 82 percent increase in 1985 poultry output as compared with 1970. This represents anticipated growth at an average compound rate of 4.1 percent per year, which is in line with developments in the 1950's and 1960's. International trade is expected to grow about in proportion to the growth in world output.

Like pork production, poultry output follows distinct husbandry systems in different parts of the world, differentiated primarily by the affluence of the farming population and cost and availability of feeds. The confined production of poultry, however, is based on technology that is now broadly understood and worldwide in application, and on feed mixing and hybridization of producing and breeding birds.

Gleaning and scavenging of feeds and seeds are important sources of poultry feeds in developing regions. Weed and insect control is

also important. Ducks and geese largely care for themselves by gleaning in the irrigation waters of rice-producing regions.

The United States

Broilers--Broilers are young chickens 6 to 10 weeks of age. U.S. broiler production has risen from 34 million birds in 1934 to more than 3 billion birds in 1973 (1). Per capita consumption of broilers rose from 0.5 pounds in 1934 to 37.7 pounds in 1973 (2). These tremendous gains in production and consumption result from new production and marketing technologies and changes in the economic structure of the industry--resulting in prices to consumers increasing less than those for competing meats. A general rise in real per capita disposable income also has been a factor.

Since the 1930's the broiler industry has changed gradually from one characterized by small independent farm flocks and small processors to an efficient, highly integrated industry. A typical production unit now consists of a hatchery, a feedmill, a processing plant, a field service and management staff, and 150 to 300 contract growers. The economies of scale gained in processing and other activities associated with large integrated firms, as well as the improved efficiency in broiler production, have allowed the broiler industry to hold down or decrease many production and marketing costs.

Advances in production technologies through genetic research and development, improvements in poultry nutrition, and improved management practices have enabled the broiler industry to produce a 3.5-pound live broiler in 7-8 weeks instead of the 12-14 weeks of 20 years ago and with a feed conversion near 2.1 pounds of feed per pound of live broiler compared to 4 pounds in 1940.

Tremendous advances have been made in the past 20 years in converting plant and waste animal protein and energy into a nutritious animal protein product. It will not be easy for the scientific and technological community to match these advances in the future. Advances can be made, however, in the use of poultry waste as a feed ingredient, improved management practices and equipment to conserve energy, new preservation methods, further genetic improvements, a better physiological understanding, vaccines, etc. Such improvements could further reduce cost of production and marketing. Fuel consumption may be reduced. Alternate sources of energy may exist. Use of poultry litter as a feed for ruminants may provide an added source of income.

Although opportunities for further reducing the total cost of producing and marketing are limited, the production efficiency of broilers should make them a major source of animal protein in the future.

Turkeys--The turkey industry has changed substantially in the past 40 years. Production rose from 20 million birds in 1953 (3) to 132 million birds in 1973 (1). Per capita consumption rose from 1.7 pounds in 1935 to 8.7 pounds in 1973. The character of the turkey industry also changed over the same period. The number of turkeys per farm increased, and the number of turkey farms declined. Contract production increased from 21 percent of total production in 1955 to 42 percent in 1970. The number of processing plants slaughtering more than 15.6 million pounds more than doubled from 1962 to 1972 while the number of processing plants slaughtering less than 5.2 million pounds annually fell to less than half of the 1962 level (3).

The turkey industry has followed the trends of the broiler industry in changes in marketing structure, size of farm, production technology, and demand increases. However, the turkey industry is not yet as highly integrated as the broiler industry. It also has more cooperatives.

Processed turkey products, such as turkey rolls, roasts, ground turkey, and luncheon meats, have expanded the market for turkey. The year round processing and consumption of these processed products has helped reduce the seasonality of demand; thus, the fourth quarter per capita consumption of turkey fell from 57.4 percent of total annual consumption in 1963 to 46.1 percent in 1972 (3). The demand for turkey, particularly processed turkey products, is expected to continue to increase in the future.

Turkey production should continue to increase, but it will do so at a slower rate since many of the economies of scale and technology have already been captured. Feed conversion for 12-14-pound hens has been lowered to nearly 3 pounds of feed per pound of live turkey and may be reduced even further. Through a combination of genetic, nutritional, and management developments, feed conversion may be lowered to 2.5 pounds or less for small broiler-fryer-roaster turkeys and to less than 3 pounds for the heavier hens and toms. However, the ability of technological advances to reduce costs in the future will be limited by higher energy costs and the costs of meeting environmental standards in production and processing.

The raw carcass of young market turkeys has more than 20 percent protein and only 6 percent fat (7). Therefore, it has potential to supply animal protein in world feeding.

Ducks--The duck industry, though small, may have a good potential. Ducks grow well on very simple feeds. They convert poor quality feeds into a high-energy food for humans.

Eggs--The egg industry, like the broiler and turkey industries, has undergone many structural and technological changes in the past 25 years. In the 1950's, 400 million layers produced about the same number of eggs now produced by less than 300 million layers. These are on fewer but larger farms.

Egg production has not risen as dramatically as broiler or turkey production since the aggregate demand for eggs has been declining for more than two decades. Per capita shell egg consumption fell from 364 eggs per year in 1950 to 272 in 1972, while per capita consumption of processed eggs rose from 25 in 1950 to 35 in 1972 resulting in a net decline of 82 eggs per year per person from 1950 to 1972 (5).

Advances in production and marketing technology have made it possible to produce and market a higher quality product while maintaining a lower retail price from 1951 through 1972. (If these prices were deflated, the reduction in cost to the consumer would be even more apparent.) The annual rate of lay per layer increased from 174 in 1950 to 227 in 1972. The number of eggs sold per farm increased from 1,600 dozen to 13,600 dozen from 1954 to 1968 (6). The industry has become more vertically and horizontally integrated and many large fully integrated production, assembly, and processing units now exist in all regions of the United States. Over the past two decades, output expanded fastest in the Southern and Western regions. Contract egg production has also increased.

The improved production of layers has led to better feed conversion, increased egg production, and improved interior quality. Poor shell quality continues to be one of the major causes of economic loss, particularly at the farm and retail level.

Management practices and production facilities have changed considerably with the advent of caged production and with mechanized feeding and egg collection. The seasonal production pattern has also changed from that of the 1950's when monthly late winter and spring production was as much as 60 percent greater than early fall production. Monthly production is now fairly constant. This has come about largely because of better, environment-controlled housing that uses more insulation, improved ventilation techniques, and improved lighting practices. Further improvement is possible through even better temperature control in poultry houses.

Processing and packing operations are generally located in producing areas. Assembly, grading, processing, cartoning, and labeling have been mechanized; thus eggs can be processed quickly and efficiently in large-scale plants with less labor. The egg breaking and processing industry has changed from a seasonal surplus egg operation to an established year-round secondary demand for eggs. The size of the eggbreaking plants has also increased.

As the cost-reducing effects of new production and marketing technologies diminish, the egg industry may find itself in periodic cost-price squeezes, particularly if egg demand continues to decrease. The potential decreases in feed conversion to perhaps less than 4 pounds of feed per dozen eggs and additional production and processing efficiencies may be more than offset in the future by higher energy, labor, and material costs.

RESEARCH NEEDS

The following were identified as the important problems that require research related to poultry.

Rank Order		
		Production
1	SP	Develop methods to improve the control and prevention of the following diseases and their effects: Newcastle, avian influenza, airsacculitis, infectious bursal disease, mycotoxicosis, fowl cholera, inclusion body hepatitis, coccidiosis, pathogenic mycoplasma species.
2	SP	Develop and evaluate alternate sources of feed which do not compete with human food requirements.
3		Develop labor-saving equipment that complies with standards set by OSHA and USDA and maintains high levels of yield and grade.
3		Develop accurate information on the nutritional requirements of present-day broilers, breeders, turkeys, and commercial laying hens.
5	SP	Improve the rate of lay, particularly in turkey and meat-type chickens; increase the length of laying periods and decrease the intervals between them.
6		Analyze the cumulative impact of governmental regulations on productivity and cost.
9	SP	Improve eggshell strength and texture, especially after 9 months of lay.
9		Develop uniform methodology for accurate and timely feed ingredient analysis and provide this data to industry through national or regional data banks.

Rank Order		
		Production (continued)
12		Develop a baseline model for nutritional research to enable all nutritionists to utilize the work of others.
13		Determine if present trade standards and specifications for feed ingredients are adequate to meet industry's needs.
15		Develop labor-saving devices for hatching-egg production.
17	SP	Improve structures to give best control of light, temperature and humidity for high productivity and efficient use of resources.
19		Develop a more efficient method of catching live broilers.
	S	Determine best methods of recycling poultry wastes including handling methods and identification of heavy metal and other residues.
	S	Determine the most effective balance of dietary and environmental energy consistent with best feed utilization and resource conservation.
	S	Determine the best conditions (including reduced stress and disease) to attain most efficient feed use.
		Marketing and Processing
6		Develop and improve shell-egg processing practices in marketing eggs and egg products.
11	SP	Develop methods for most effective use of byproducts from slaughter and of wastes from hatcheries and processing plants.
15	SP	Develop new, nutritious, and wholesome products from poultry meat, eggs, and byproducts with improved consumer acceptance.
17		Develop an improved and more efficient inspection system while maintaining at least the same degree of product wholesomeness.

Rank
Order

Marketing and Processing (continued)

S Investigate ways to reduce skin diseases and blemishes and improve bone strength in broilers to prevent downgrading in processing.

Consumer Needs

8 Improve internal egg quality.

14 Reduce cholesterol level in shell eggs.

20 Determine the effect on human health disease of a diet containing high levels of chicken and turkey meat.

S Reduce bacterial and other contamination throughout the marketing chain in order to improve wholesomeness and reduce waste.

S Develop a faster test for salmonella; develop methods to eliminate organisms like salmonella in food products without affecting nutrition or quality ("pasteurization" of egg products).

S Design monitoring programs to detect pesticides and heavy metals in poultry meat and eggs and to help determine the source and chain of transmission.

S Prevent potentially harmful residues in poultry products.

S Determine whether mycotoxins can be transmitted through poultry into meat or eggs.

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10.3 AQUATIC FOODS

Objective: To increase the quantity, quality, and diversity of aquatic foods to meet requirements for human foods having nutritional and economic advantages and to do so with ecological efficiency in the use of freshwater and marine resources.

SITUATION (1)

The situation in aquatic foods differs from that in nearly all other food sources in that some 90 percent of the supply of aquatic foods comes from wild stocks. About the only effective control that now can be exercised by man is to manipulate rates of harvesting so that the wild stocks will continue to yield at the highest rates possible consistent with their preservation and conservation.

Wild aquatic food stocks have traditionally been considered a common property resource, belonging to no one until they have been harvested. The only significant variation on this policy in the past has been the declaration by various political divisions from the level of nations to the level of townships that the aquatic food resources within certain boundaries belong to the inhabitants of that political division and that harvest "rights" will be limited to those inhabitants. In general, this policy has not contributed significantly in ameliorating the "tragedy of the commons," since the number who may participate in the harvest has not been limited effectively.

These problems have been recognized by the United Nations Law of the Sea Conferences, most recently in Geneva in the spring of 1975, but after several years the LOS Conferences have not been able to agree on an effective treaty for the protection of living aquatic resources. It appears likely that many major fishing nations, the United States among them, will take unilateral action within the next year or so to declare jurisdiction over aquatic food resources off their shores and to manage these resources.

The Food and Agriculture Organization of the United Nations has estimated that potential annual yield of conventional species of marine fish, crustaceans, and molluscs from the world ocean is well over 100 million metric tons. By 1974, catches had increased to the point at which about 50 percent of the potential was being harvested.*

*Here and in the following paragraphs, if weights are not otherwise specified, they are in terms of the whole animal as captured. Conversion of these weights to weight of edible portions involves factors varying from about 0.3 to about 0.1.

Increases in catches from 1938 to 1973 have been 350 percent for freshwater species and 197 percent for marine species. These increases progressed in a reasonably orderly fashion until the 1970's, but a decrease occurred in 1972 when the Peruvian anchovy catch dropped to 5.4 million tons from its 1970 high of 13.1 million tons. The anchovy catch dropped even further in 1973 to 2 million tons and is expected to continue low for at least a few more years, although it increased in 1974 to 3.6 million tons. This single species, whose catch approached 20 percent of the world catch in 1970, will undoubtedly cause further perturbations in world catch statistics for some years to come.

The anchovy phenomenon points out that the implication that world catches of conventional species can be doubled over their 1974 level has to be qualified. An increasing number of species are now fully exploited or overexploited, and it is becoming clear that management action is needed to assure realization of the full potential of the conventional species.

A total yield several times in excess of 100 million tons may be possible if harvesting turns to less familiar types of marine animals. An example is squid and other cephalopods, heavily fished in a few areas, but almost unexploited in others. Other examples are the krill of the Antarctic and the lantern fish of warmer oceans. Harvesting and marketing of these less familiar species on a large scale presents serious technological problems. Nonetheless, some experts have estimated that the total sustainable annual harvest of all species might be on the order of at least 150 million to 300 million tons.

There are other ways in which the production of food from the sea could be increased. One is the diversion to the direct food market of large amounts of species now used for fish meal, such as menhaden and Peruvian anchovy. While a large part of the fish meal production eventually finds its way to the world's table as feedstuffs for poultry and other animals, a good deal of the food value is consumed in conversion.

It has also been estimated that the total useful fish production could be increased by some millions of tons by elimination of waste. A great deal of fish is thrown back into the sea as "trash" by vessels fishing for other species, especially by shrimp fleets. Other large amounts are lost after catching by improper handling, preservation, and storage. Reduction of waste in processing can also increase yields substantially.

It has often been said recently that worldwide marine harvests are falling because traditional waters have been overfished or polluted. World marine fish and shellfish catches peaked in 1970 and 1971 and

then declined in 1972 and 1973. These gross catch figures must be interpreted carefully, however, in light of the facts that fresh-water fisheries, high seas (as opposed to coastal) fisheries, fisheries for shellfish, and fisheries in warmer ocean waters have been increasing over the past several years.

The answer to these apparent contradictions is that the drop in total catch was caused almost solely by the precipitous decline in catches of anchovies off Peru and Chile. Examination of world marine fish and shellfish catches, excluding the Peruvian anchovy, shows a reasonably uniform rate of increase of about 6 percent per year from 1955 to 1973, about three times the rate of growth of world population.

World catches have not, of course, been equally distributed among countries, nor have the increases been equally distributed among the major fishing countries. Japan, Peru, the U.S.S.R., China, Norway, and the United States accounted in 1973 for just over half of the total world catch. Only 14 countries had catches exceeding 1 million tons in 1973, but the catch of these 14 countries accounts for nearly two-thirds of the world catch.

The United States has been left behind in the increase of world catches that has taken place since the late 1930's. The anchovy fishery brought Peru from an insignificant catch to a position of world leadership, and the catches of Japan, the U.S.S.R., China, and Norway have increased from 170 to more than 470 percent. Present U.S. catches, on the other hand, are comparable to those prior to World War II and are actually less than those of the late 1950's and early 1960's.

Although the gross U.S. commercial catch has been remarkably stable since 1938, its distribution and composition have changed drastically. Some of these changes are the result of growth in the menhaden, shrimp, and tuna fisheries, up 2.5 to 4 times over their 1938 levels. (Of course, a very large part of the U.S. tuna catch is taken in distant-water fisheries and not off U.S. shores.) On the other hand, salmon catches are only a third of their 1938 volume; haddock catches are only a twentieth, and the formerly important California sardine fishery has practically ceased.

Continental shelf areas within 200 miles of U.S. shores account for about 9 percent of the shelf area of the world, excluding the Antarctic. However, most of the world's marine fishery production comes from the temperate and subarctic shelf areas. About 20 percent of these areas of the world lies within 200 miles of U.S. shores.

Fish and shellfish stocks off U.S. coasts are an enormous and valuable renewable resource. Total annual catches by U.S. and foreign commercial fleets are about 6.3 million metric tons a year. In addition, there is a U.S. recreational catch of at least 0.7 million metric tons. Assuming a retail price of 60 cents a pound for commercial and recreational catches gives a total estimated retail value for present catches of about $9 billion per year.

Despite the rich resources off our shores, total U.S. imports roughly tripled from 1950 to 1974. In the early 1960's, imports began to equal and then to exceed U.S. commercial production. Imports of edible fishery products have increased steadily and quadrupled from 1950 to 1974. Imports of inedible fishery products, consisting largely of fish meal, peaked in 1968. Since 1968, fluctuations in fish meal supplies (largely from Peru) and prices have reduced imports of inedible products in 1973 and 1974 to their lowest levels since 1950.

A comparison of the species being taken by foreign fisheries off the United States and the products imported by the United States shows little correspondence. In fact, the United States has distant-water fisheries for tuna, shrimp, and lobsters, which make up half the volume and value of U.S. imports.

Aquaculture (2)--Aquaculture, defined as the culture and husbandry of aquatic animals and plants, provides some 10 percent of the world aquatic food production. Present production of fish, shellfish, molluscs, and seaweeds amounts to about 6 million metric tons. The majority is produced in mainland China (2-3 million tons) and is comprised primarily of various species of carp. Carp are also the major species raised in other areas of Asia, Europe, and the Middle East. Other organisms produced in great numbers on a worldwide basis include tilapias, milkfish, mullet, trout, yellowtail, salmon, oysters, mussels, clams, and shrimps. Aquaculture production normally provides food for local or regional consumption.

In the United States, private commercial marine aquaculture accounts for some 9,100 metric tons (excluding shell weight) of oysters and about 450 metric tons of pen-reared salmon (salmon catch attributable to public aquaculture is now more than 27,000 metric tons). Freshwater aquaculture, primarily catfish and trout, is practiced on about 65,000 acres with a total production of about 39,000 tons. Experimental efforts are in progress on shrimp, freshwater prawns, Pacific salmon, lobsters, marine plants, crayfish, clams, oysters, scallops, and various freshwater species.

Aquaculture has a high potential for increasing world production of fishery products through the development of new systems, using additional species, improved management techniques, and the development of sound ecological approaches to fish culture. There are many large unutilized and underutilized areas in many parts of the world suitable for aquaculture. Major constraints to large-scale development of aquaculture in the United States are biological, economic, and technological, compounded in some cases by institutional problems. Biological knowledge for some species is now available, but the technology needed for commercial production is frequently lacking.

Fisheries and Energy (1)--Fish is eighth of nine food groups in the ratio of energy content to energy used for production. In the ratio of energy use to protein content, however, fish leads the nine groups and is more efficient than meat and poultry by perhaps one-third. Coastal fishing is reasonably efficient, at about the same energy-use level as milk from grass-fed cows. Distant-water fishing, on the other hand, is one of the most inefficient means of food production and can be compared to feedlot beef production. However, as man cultivates marine foods more intensively in aquaculture, the energy cost of production rises.

Current Technology (1)--The technology of food production from aquatic sources probably antedates any other food technology still used. The hooks, traps, and nets used by today's fishermen vary surprisingly little from those used in ancient times, and a substantial fraction of the world's fish is taken by artisanal methods.

Three revolutions have occurred in fishing. The first was the large-scale conversion to powered vessels early in this century. The second was the development of improved navigation and fish-finding methods after World War II, and the development of the power block for net handling. The third was the development of factory fleets, mostly by the U.S.S.R. and Japan, capable of overfishing a stock of fish in a year or two--in contrast to the decades required previously.

RESEARCH NEEDS

The following were identified as the important problems that require research related to aquatic foods.

Rank Order

Production

1 SP Close gaps in knowledge of key aquaculture species--spawning, larval rearing, environmental requirements, nutritional requirements, economic feeds and feeding systems for cultured species, including management of aquatic plants.

Rank
Order

Production (continued)

Rank Order		
3	SP	Measure the abundance and distribution of aquatic food resources during their early life stages and measure the distribution of all commercially harvestable fish and shellfish.
6	SP	Develop methods of selective breeding, genetic modification, management, harvesting, and environmental control for cultured fish and shellfish (aquatic species).
7		Develop more efficient harvesting techniques for wild resources to include search techniques, exploratory fishing, vessel and gear design, and onboard handling and preservation methods.
8	SP	Develop techniques to scientifically manage harvesting in order to maintain or restore aquatic food resources through a system of State/Federal management programming.
9		Develop technology to utilize noncompetitive products and byproducts from various sources to supply nutritional needs of cultured species.
9	SP	Develop methods to recognize, prevent, and treat diseases.
13	SP	Use data collected from commercial and recreational fisheries and scientific surveys to evaluate and predict the condition of fisheries resources.
15		Develop economical depuration for fish and shellfish production.
16		Strengthen statistical collection systems for fisheries and develop a responsive reporting system to the user community.
17		Research the use of holding ponds on livestock and poultry farms as an environment for fish culture.

Marketing and Processing

2	SP	Develop more efficient processing methods to make possible a net increase in yields from aquatic resources and develop a system of collection, waste utilization, and byproduct development.

Rank Order		
		Marketing and Processing (continued)
5	SP	Improve processing, handling, and storage methods to reduce deterioration and locate points in the marketing chain where spoilage most often occurs and find ways to prevent it.
12	SP	Develop processing, handling, and storage methods to prevent health hazards from microorganisms.
14		Design a new nomenclature system for fishery products.
17		Develop a data bank system for microconstituents and nutritional composition information for future nutritional labeling.
19	SP	Determine how existing institutional and legal constraints affect the supply and use of aquatic foods.
	S	Improve recovery of fish protein through better and more efficient processing.
	S	Develop information that will reduce economic losses due to unstable supply/demand.
		Consumer Needs
3		Develop a national policy for U.S. fisheries.
9		Study the interdependence between fishing interests, oil and gas interests, coastal zone interests, and recreational interests to maximize the protein yield from aquatic sources.
20		Develop means to analyze potential human and environmental hazards from chemical residues in aquatic foods.
	S	Develop new products to expand the variety of seafoods available to the consumer.

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11.1 HUMAN RESOURCES

Objective: To utilize fully human resource potentials and to improve them to the fullest extent possible consistent with meaningful labor force participation and productivity in agricultural industries.

SITUATION

The World

People constitute the world's most important resource. But people must act in conjunction with land and capital if they are to exist. Inventiveness plays an extremely important role in enhancing the well-being of people. According to the Economic Research Service, USDA, total world population reached an estimated 3.8 billion in 1973, a rise of 1 billion over 1957 (1). The annual increase in world population is now about 70 million people, nearly double that of 1950. Of fundamental importance in satisfying the increasing demand for food as well as many other aspects of economic and social development is the need to account for and reconcile the differing human resource requirements for effective food production.

The developing countries contain about 70 percent of the world population, and they account for about 86 percent of the annual population increase. Their demand for food increases correspondingly. Unfortunately, the competence of the labor force in the developing countries is not increasing with the needs of the expanding population. The poor quality is a function of marginalization and alienation and the need for comprehensive adaptation to technological change, cultural change, and world experience in attempting to change the nature of its agricultural plans.

Developing countries are not homogeneous. Great diversity exists among them in terms of ability to provide adequate food for domestic consumption and for export. One part of the food gap problem is that of underutilized human resource potential--i.e., the inability (or lack of incentives for farmers and others in the agricultural sector) to adopt the full combination of technologies needed to overcome the constraints imposed by ecology or the socioeconomic environment. At the same time, serious effort needs to be made to tailor agriculture to coincide with society rather than the reverse. Some of the major failures of the past two decades have come as a result of trying to introduce a quantum jump into the technology of a developing country's agriculture. Concentrating on the evolution of a modern agriculture can diminish the adjustment problems and increase the output of food greatly.

Technological changes in agriculture have led to drastic declines in labor needs in this economic sector within developed countries. Most of the redundant population has been absorbed in our expanding non-farm activities.

Despite high rates of economic development in developing countries, however, there is no assurance that the displaced rural populations can be easily absorbed there, and there is considerable concern about "overurbanization" with a rapidly growing underemployed population found at the peripheries of most large cities. This is another argument for carefully weighing the costs against the benefits of rapid technological changes in agriculture and for including in plans to increase production concern about the people most directly involved in any changes.

The growth of the rural population in most developing countries, and the vast numbers involved, would seem to argue against encouraging a too rapid decline of employment in agriculture and certainly against the facile assumption that opportunities await such people elsewhere.

Thus, three concomitant requirements are essential--a commitment to improvement of human resource potentials and alternative employment opportunities; national research organizations; and effective, socioculturally adapted extension organizations. As part of a research organization's program, attention would need to be given to providing basic data for planning and to evaluating development programs. Just as the environmental impacts of new technology and organization in agriculture must be assessed, so too must the social and economic impacts of these innovations be considered, giving attention to income distribution, the possible creation of redundant workers, and consequences for traditional community structures.

The United States

While the United States has traditionally produced food surpluses, the potentials of many of its human resources in and out of agriculture remain underdeveloped. In recognition of the vital stake the United States has in a peaceful and prosperous world, it has undertaken programs of technical assistance to developing countries. Most of this assistance has been concerned with nonhuman resource factors of production.

A revolution has occurred in American agriculture since World War II. Farms have become fewer and larger, highly capitalized, and heavily dependent on credit operations. These changes were necessary to efficiently use the technology developed in our agricultural research. But, given this change, many human resources formerly in agriculture have been left ill-prepared for alternative opportunities either in

agriculturally related activities or in the nonfarm sector. The lesson for developing countries is obvious.

Nearly half the people with poverty-level incomes in the United States are in rural areas, many still in agriculture as small farmers, farm operators under 65 years of age who work off-farm for wages less than 100 days per year and who have agricultural sales of less than $20,000 annually. Providing opportunities for these small farmers to upgrade their managerial skills can help directly address problems of malnutrition and poverty if at the same time larger-scale farmers can increase their production to satisfy domestic and export market needs.

Past research on diffusion of information and adoption of farm and home practices has made a major contribution to the effective production of the U.S. agricultural industry. However, there is need for more basic information about the agricultural labor force and rural families dependent on agriculture. The impact of technological changes in agriculture on the populations affected needs to be studied as well as the occupational and geographic mobility of agricultural people. The educational programs available should be examined, both in the context of the skills needed for agriculture and for nonfarm and urban employment. More attention needs to be given to the training and careers of supporting persons--those in marketing, extension, and rural community health and social services--and more generally to the need for, and delivery of, this support in developing countries.

Some work on the adoption of innovations should continue, but with more emphasis on the constraints under which individual farmers operate in making their decisions--in addition to their personal characteristics or traditional views.

Less than 5 percent of the total U.S. population, or about 9.5 million, is farm population. This number is crucial to producing an adequate food supply for domestic use and for export. To keep the production machine going, it will be necessary to provide the high-quality personnel and community services appropriate for the people in rural America.

RESEARCH NEEDS

The following were identified as the important problems that require research related to human resources.

Rank Order		
		Agricultural Labor
1	SP	Determine factors needed to provide an adequate farm labor supply, including both wage levels and other factors affecting the community status and self-image of farm workers.
8	SP	Investigate and propose solutions to collective bargaining problems which are characteristic of agriculture.
13	SP	Analyze the wage and other remuneration differences between agricultural and nonagricultural workers of equal proficiency.
14	SP	Develop labor management models for agricultural settings.
15	SP	Evaluate future supply and demand for human employment in agriculture, on and off farms.
	S	Determine adequate wage and work incentives for farm workers.
		Limited-Resource Farmers
2		Determine ways in which the technologies, skills, and research/education capabilities of the U.S. agricultural system can be adapted to the cultural situations of specific developing nations in order to be useful to their poorest farmers.
4	SP	Determine ways to increase productivity of limited-resource farmers.
4		Identify means of assisting, limited-resource farmers in developing nations to improve their crop storage and protection in order to substantially reduce postharvest losses.
4		Determine the types of low-cost and low-fuel-demand technologies which can be developed to assist small-acreage agriculture in the developing nations.
4		Develop cropping systems specifically designed for small farms in less developed countries to increase productivity of the farmers' land and labor.
9	SP	Develop technologies specifically designed for use on U.S. limited-resource farms.

Rank Order		
		Limited-Resource Farmers (continued)
10		Determine the present and future competitive status of single-family farms and find ways to improve it where necessary.
10		Develop small implements specifically designed for small farms in less developed countries to increase productivity of the farmers' lands and labor.
12		Evaluate existing educational programs and propose new programs to train displaced and low-income farmers for alternative employment.
15	SP	Determine the impact of economic and technological change on U.S. limited-resource farmers.
18		Evaluate alternative systems to deliver technical recommendations to farmers, particularly U.S. limited-resource farm operations.
		All Rural Residents and Workers
2		Investigate avenues for providing nutrition and health education for all Americans as an investment in human capital.
15		Analyze the relationship between human knowledge and behavioral change. (Why don't we do what we know is good for us?)
19		Determine the impact of poor health of rural residents on agricultural production in both the U.S. and developing countries.
20		Develop workable guidelines to evaluate the significance to human health of minute residues of chemical substances in all food products.

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11.2 SOCIAL INSTITUTIONS

Objective: To help rural communities and rural residents attain their economic and social goals through their own work, planning, and investments and to improve the capacity of social institutions to ensure the economic and social well being of rural people.

SITUATION

Earlier sections of this report discuss physical, biological, technological, and economic problems in reconciling U.S. and world food production with expanding food demand. Human resource problems are also analyzed. Of equal or even greater importance are the social institutions that affect the ability of rural people to achieve adequate living standards and a satisfying life.

Much of the social legislation passed in the United States during the 1930's in response to depressed economic conditions excluded farm people. Government programs on behalf of farmers consisted mainly of commodity price guarantees and supports, provided and administered through a variety of programs. Exclusion of farmers from social legislation was compounded by accepting farm programs as substitutes for general social programs. An example is the early exclusion of farmers from coverage under the Social Security Act. At the time of enactment, it was argued with the concurrence of farm organizations that price supports were the farmers' equivalent of Social Security. Subsequently, the exclusion was removed as evidence mounted that aged farmers were typically in bad financial condition at retirement.

The tendency to exclude farm people from social legislation was reversed to some extent in the 1960's. Rural communities were included in the Area Redevelopment Act and special rural communities development legislation was passed. Farm and rural people were included in economic opportunities legislation, and underemployed as well as unemployed farm individuals were included in the Manpower Development and Training Act of 1972. Farm and rural people also have been included in pilot programs for relocation assistance and public employment. For the most part, achievements in these areas have been modest.

Research on social institutions has been largely informational and policy-oriented and has been carried out in the areas of health and education, housing, and government services and facilities. Research

in these areas has made major contributions to knowledge about the level and quality of social overhead.

Although research tools to measure quality are not readily available, evidence indicates that metropolitan areas surpass rural in certain kinds of health care and in some aspects of the educational process. Rural areas generally lack specialized medical services and fully accredited hospitals. Although there is a rural-urban difference in median years of school completed up to about 12 years of schooling, it is mainly in post-high school education that urban areas have the better record. To the extent that post-high school education adds significantly to average lifetime earnings, this relative deficit in education constitutes a substantial disadvantage.

Research on housing, an important social component of successful rural development, has provided important information on the conditions of existing housing and projected demand in rural areas.

Research on government services and facilities indicates a widening gap in per capita expenditures on government services between urban and rural areas. The local tax base, essentially the property tax, does not keep pace with the increasing demands on it and an increasing portion of the revenue of local governments is coming from State and Federal aids. However, these aids have not been adequate to provide the needed rural services.

RESEARCH NEEDS

The following were identified as the important problems that require research related to social institutions.

Rank Order		Research
2	SP	Determine how best to plan, conduct, organize, finance, and share the results of U.S. agricultural research and to eliminate duplication while retaining useful replication.
8		Evaluate alternative institutional arrangements by which less developed countries may conduct agricultural research, linking in with international agricultural research centers, and by which research results may be made available to farmers in those countries.

Rank Order		
		Local Government
5	SP	Develop techniques to help local rural governments do a better job of analyzing alternative solutions to their problems.
8	SP	Evaluate alternative revenue sources for rural local governments.
16	SP	Evaluate the capabilities and potential of multicounty districts to provide professional planning, research, and other expert services to rural local governments.
	S	Evaluate the effect of number and size of rural governmental units on the ability of people to influence local governments.
		Facilities and Services in Rural Areas
6	SP	Analyze effects on the quality of rural life of cultural, educational, health, housing, communication, transportation, and other services; evaluate alternate ways of improving them.
7		Develop incentive systems for attracting health facilities, educational opportunities, and other services to rural areas.
8		Evaluate the comparative advantages and costs of voluntary versus governmental provision of services to rural America.
17	SP	Determine demands for alternative services and evaluate the cost and feasibility of alternative ways to provide services to low-density areas (e.g., rural Wyoming).
19	SP	Evaluate the effect of number and size of service units on the cost and range of nongovernmental services in rural areas.
20		Study the feasibility of multiagency linkages for communicating with and delivering human services to a single client population in rural America.
	S	Develop ways to measure adequacy of governmental and nongovernmental services in rural areas.

Rank
Order

Socioeconomic and Institutional Well-Being

1 Evaluate existing and proposed land tenure and capital mechanisms designed to encourage young people to enter farm operations.

3 Evaluate the impact of State and Federal tax policies on retaining the family farm.

4 Evaluate alternative methods of land use control which reflect the interests of local citizens.

8 Determine changes needed in existing institutions to provide adequate energy supplies at minimum feasible cost.

12 SP Evaluate the contribution of rural industrial development toward improving the opportunities of rural people.

13 Evaluate the successes and failures of cooperative-type institutions in meeting the needs of limited-resource farmers, in both the U.S. and in the less developed countries.

14 Identify means by which the U.S. land-grant agricultural research and education system can aid rural development in less developed countries through linkage with indigenous institutions and communities.

15 SP Develop analytical tools for measuring differences in quality of rural and urban well-being.

17 SP Analyze the effects of policies that promote growth in rural areas versus policies that promote outmigration.

20 Study and propose ways of nurturing the public through the resources of the land-grant universities given the potential of a concerned general public in the U.S. (e.g., in labor unions, religious organizations, and other voluntary associations) for informed, positive involvement with world food policy questions.

S Evaluate the job hopes of rural people in relation to real employment opportunities in the national economy.

12.0 MARKETING SYSTEMS

Objective: To identify and find solutions to problems that impede the efficient performance of the marketing system in (1) providing the storage, transport, processing, and distribution services needed to make food available to consumers at the lowest possible cost, (2) reflecting consumer needs and preferences, and (3) properly allocating resources and returns in production and marketing.

SITUATION

In a highly developed economy such as ours, specialization and a high level of technology in production are possible only when accompanied by a responsive and efficient marketing system. From a general economic viewpoint, our food production system and food marketing system cannot be viewed as separate or independent of each other. Problems that would adversely affect the performance of our marketing system must be identified and resolved if our food production capacity is to be used to best advantage in meeting the food needs of the consumers of our Nation and of the world.

The function of the marketing system is to move food products from producers to final consumers while providing utility of time, place, and form. Making food available when consumers want it requires a large amount of storage and processing. Placing food where consumers want it requires the assembling of products from farms across the country. As this is done, the products have to be sorted for uniformity and combined into units suitable for ease of handling and shipping. On the way from producer to consumer, food moves through packers, processors, warehouse operators, and wholesalers. This is a continuous process and requires constant effort to preserve quality and wholesomeness. Finally, the myriad of wants and expectations regarding food result in a wide-ranging demand for variety in the forms of food.

The U.S. food marketing system has been oriented largely to the rising affluence of our society. In response to rapidly rising income and education, the system has put more convenience and variety into our food products. This has been achieved mainly through experimentation with new products.

Over the past several decades, common ownership of successive stages or functions of marketing has been increasing--thus eliminating ownership transfers, insuring and controlling volume and quality of

supply, and increasing the scale of overall enterprise. As a result, there has been a decline in number of firms and emergence of larger firms and conglomerates.

Rapidly rising food prices, world food shortages, and domestic nutrition problems have intensified concern about the performance of the food marketing system. These concerns include product waste at all levels of marketing; a proliferation of products and services that increase marketing costs; the amount of nutrition versus service built into products; and the inflexibility of mass marketing in face of the needs of specific disadvantaged population groups. Also, marketing costs and margins for food have been rising rapidly. About two-thirds of U.S. consumer expenditures for food are accounted for by the marketing system.

Changes in the structure of the food marketing system have raised questions about its competitiveness, efficiency, and possible misuse of economic power; and whether price determination is based on supply and demand. The increased role of administered pricing and the lower volumes of products exchanged in competitive markets raise additional questions as to pricing efficiency in food distribution. The process of new product experimentation is probably beneficial to affluent members of society but may create problems, especially for disadvantaged consumers. It also raises questions about tradeoffs between service and nutrition.

RESEARCH NEEDS

The following were identified as the important problems that require research related to marketing systems.

Rank
<u>Order</u>

<u>Structure, Conduct, and Performance</u>

1 SP Evaluate the need for new price discovery techniques between buyers and sellers.

1 Identify and evaluate opportunities for greater marketing efficiency through standardizing and modularizing containers and packages.

3 SP Develop reasonable norms in food sanitation and safety regulation.

3 Develop comprehensive information on consumer behavior and demand for food including elasticity of demand and relationship of food demand to other goods and services.

Rank Order		Structure, Conduct, and Performance (continued)
5		Determine the export demand for U.S. farm products and the impact of this demand on the composition and quantity of U.S. production and commodity prices.
5		Evaluate the impact on domestic producer and consumer prices of export purchases and sales by State trading organizations and international cartels.
5		Evaluate ways prices can be more accurately identified and reported to meet the needs of producers, marketers, and consumers.
9	SP	Examine the impacts of labor practices and agreements on costs and marketing practices.
9	SP	Evaluate the conduct and performance of various organizational systems, scale of operations, handling methods, or other structural dimensions of markets.
13	S	Evaluate the role of technology in food marketing including incentives required to improve such technology commensurate with desired consumer services.
13		Evaluate regulatory constraints on the structural configuration of the food industry.
15		Determine the short- and long-run implications of alternative forms of export control on production stability of foreign markets and on domestic commodity prices.
15		Analyze the cost and benefits of regulations by Federal, State, and local governments.
17		Develop and define norms for measuring market performance such as efficiency profits, equity, responsiveness, consumer satisfaction.
17	SP	Evaluate changes in energy availability and impact on marketing costs and identify and evaluate alternative marketing practices which will reduce costs.
20		Develop more definitive marketing margin and cost information to meet the need of various interest groups in evaluating market performance.

Rank Order		
		<u>Structure, Conduct, and Performance</u> (continued)
20		Develop comprehensive information on consumer needs and attitudes.
20		Evaluate the impact of vertical integration in food production and marketing related industries.
	S	Identify and analyze price policies and exchange arrangements among groups of market participants.
	S	Evaluate costs and profits of alternative organizational systems, scale of operation, handling methods, and level of technology.
	S	Examine the cost impacts of health and labeling requirements and other governmental regulations.
	S	Develop norms for public surveillance and guidance in the areas of food safety, food advertising, and consumer information.
	S	Develop input-output data for various segments of industry and types of business.
	S	Develop information for consumers about the composition of retail prices.
	S	Determine what marketing services are available to low-income consumers and what kinds of services they need; evaluate costs and benefits of food stamps and alternatives that deliver more nutrition and fewer marketing services.
	S	Establish public data series which identify the food additives of conglomerate manufacturers.
		<u>Transportation and Storage</u>
5	SP	Identify and evaluate methods and procedures for reducing transportation costs such as back haul, unit trains, intermodal.
9	SP	Evaluate the economic impact of transportation deregulation, abandonment, and other forms of transportation regulation law and policy decisions.

Rank
Order

Transportation and Storage (continued)

9 SP Evaluate present and future transportation and storage requirements or needs for moving products from producer to consumer.

20 Investigate new and improved packaging which will improve product quality and reduce cost.

S Compare costs of (1) scheduled transport flows and (2) variable flows in accordance with varying production and demand requirements.

S Evaluate storage and transportation losses and costs for fresh, canned, frozen, and dehydrated foods.

S Determine quality losses or waste associated with types of storage.

Spoilage and Loss of Quality

S Measure spoilage waste in the forms of lost product, lost value, and reduced quality throughout the food marketing systems.

S Determine costs and benefits of sanitation and quality control programs.

S Determine costs and benefits of reducing or controlling losses.

13.1 PRODUCTION INPUTS AND SERVICES

Objective: To ensure an adequate and stable supply of production resources.

SITUATION

Agricultural Chemicals

Agricultural chemicals--primarily fertilizer and pesticides--have been major factors in increasing agricultural productivity in the United States and worldwide in the past half century.

Fertilizer is the primary input in the production of crops. In 1974, it accounted for 8 percent of all expenditures for agricultural production. It accounts for more than 30 percent of the variable cost of producing corn in some areas, and it ranges as high as 41 percent of the variable cost of producing wheat.

Although pesticides account for only about 3 percent of farm operating expenses, they are essential to commercial agriculture. For the five-State Lake Michigan area, for example, it has been estimated that without pesticides, crop and livestock production would just about cease and vegetable production would drop by 75 percent.

Recent shortages of fertilizer and pesticides point out the need to have a complete understanding of the systems that provide and use these inputs. The manufacturing industries cannot provide an adequate and stable supply of fertilizer and pesticides without the information essential for responsible decisionmaking. Nor does the mere existence of land or human resources guarantee their availability and effective combination with agricultural chemicals or other resources.

The continual need to adjust the agricultural chemical industries and their complex interrelationships with other components of the highly dynamic food and fiber sector raises numerous areas of concern and informational need. Annual variations in the domestic and foreign demand for food and fiber, unusual weather patterns, changing consumer preference, the industrialization of agriculture, and its continual growth necessitate unceasing adjustments in the use of resources and the system for providing them.

As a Nation we are now approaching our postwar maximum acreage under cultivation. In the important grain-producing States, cultivated acreage is already at historic highs. Consequently, specific concerns

relating to the availability and use of agricultural chemicals must be raised. Over the past quarter century, manufactured inputs required for food production rose from 40 to 60 percent of total inputs. Total tonnage of fertilizer use increased sixfold, while the use of nitrogen increased by an amazing 31 times over its use in 1950.

Ensuring adequate fertilizer and pesticides to meet rising food demand requires systematic collection of additional information in order to determine available supplies, alternative uses, price levels, and market structure. This will help in early identification of potential supply shortfall and in the analysis of productivity and interrelationships among all subsectors impinging on the food industry.

Farm Equipment and Supplies

An important factor in farm productivity has been the increased reliance on machinery and equipment and the concomitant sharp decline in labor input. The call for increased food output from a near maximum level of cultivable and productive land makes critical the need for continued availability of farm machinery and other production inputs to farmers.

The demand for farm machinery typically fluctuates in cycles and is closely related to variations in net farm income. Unprecedented net farm income in 1972-74 led to unprecedented demand for machinery in those years. Although manufacturers were producing at full capacity, the supplies of many types of machines, e.g., tractors and combines, were inadequate to satisfy demand, and inventories dropped precipitously. As a result of these and other factors, machinery prices climbed sharply in the past 2 years.

The cyclical behavior of demand has had an important effect on the structure and operating conditions of the industry. Typically, manufacturers with smaller shares of the market have fared worse in market declines than have the larger firms. Past declines have led to the consolidation of manufacturers and, in some cases, reduced production.

At present, the supply and demand situation appears to be loosening. Inventories of machines ready for sale are increasing while, concurrently, the rate of increase in the wholesale price index for agricultural equipment has slowed. Retail sales are slowing from their record levels, as an extraordinary number of machines has been added to the stock of equipment on farms.

Further loosening of the market is indicated by a likely significant decrease in demand in the next 1 or 2 years. The extent of this reduction, however, will likely be heavily dependent on farm prices and their effects on farm income. The rate of increase in machinery prices should continue to slow as inventories return to normal levels.

Ensuring adequate input resources to meet increased food demand requires the systematic collection of additional information. The shortages of machinery and significant price increases experienced in the recent past indicate that a closer monitoring of the supply and demand characteristics of the industry is desirable. This will assist in early identification of potential supply shortfall and steps which may be taken to alleviate the situation.

RESEARCH NEEDS

The following were identified as the important problems that require research related to production inputs and services.

Rank Order		
		Productivity
1		Develop nitrogen fertilizer production processes independent of natural gas or crude oil derivatives; concentrate on use of coal for ammonia production.
2	SP	Improve efficiency of photosynthesis, that in turn will improve efficiency of all inputs--CO_2, water, or nutrient elements.
3		Analyze long-term sources of economical raw materials for fertilizers, pesticides, farm equipment, and other production inputs.
4	SP	Investigate and develop new sources of energy (solar power, wind power, tides, fusion, etc.).
5	S	Develop equipment and processes for economical mechanization of green plant protein extraction, consolidation, and storage.
5		Improve crops' utilization of fertilizer nutrients.
7	SP	Evaluate priorities for use of various sources of energy in production, processing, and distribution of food.
7		Develop mining techniques to utilize potash ores.

Rank Order		
		Productivity (continued)
12		Improve diagnostic means for determining nutrient applications.
13		Determine effects of nutrients on crop and/or food quality.
14		Determine needs for secondary nutrients and micronutrients.
15	SP	Research the area of energy conservation and energy alternatives in crop drying.
16		Improve methods of fertilizer placement, relative to crop recovery and environmental aspects, as new tillage/cropping practices are developed.
16		Determine the nature of tropical soils as they relate to fertilizer use and needs; develop improved fertilizers for use in the tropics.
19		Evaluate priorities for use of animal-digested and other wastes such as fuel, fertilizer, reuse as animal feed, etc.
20		Develop equipment principles to improve efficiency of crop harvest, especially the cutting, gathering, threshing, and separating principles of grain harvest.
		Supply and Demand
7	SP	Evaluate the input requirements of new technologies such as integrated pest management, nitrogen fixation, etc.
7		Develop fertilizer demand estimates with various options of inputs (i.e., land, water, labor) for future food production.
20	SP	Determine the contribution of various inputs to agricultural productivity.
	S	Develop demand estimates for agricultural chemicals.
	S	Develop demand estimates for major types of farm equipment.
	S	Investigate the supply of various agricultural inputs.
	S	Develop and improve supply data system.

Rank
Order

Supply and Demand (continued)

S Develop demand estimates for other inputs and services.

S Evaluate alternative methods of organizing input systems and agricultural production.

S Evaluate alternative systems for supplying farm machinery and identify barriers, if any, that limit their performance.

Policies

7 Develop workable guidelines to evaluate the cost/risk/benefit ratio of minute residues of chemicals in food and their significance to human health.

16 Assess environmental impacts of nutrients in crop production.

S Evaluate alternative public policies on supply and adequacy of energy.

S Evaluate alternative public policies on supply and adequacy of agricultural chemicals.

S Evaluate alternative public policies on farm machinery supply.

Current Conditions

S Obtain yearly fertilizer and pesticide use data.

S Obtain more frequent and more accurate data on supply or availability of fertilizers and pesticides.

S Analyze and describe the fertilizer industry, including structure and cost data.

S Analyze and describe the pesticide industry, including structure and cost data.

S Develop more detailed price indexes for farm machinery and motor vehicles.

S Develop price indexes for agricultural chemicals and fertilizers.

S Analyze and describe the farm machinery industry, including structure and cost data.

13.2 PRODUCTION SYSTEMS

Objective: To effectively utilize resources available for food production.

SITUATION

The systems used by farmers to organize and manage their resources affect critically the supply and cost of food to consumers. Just as the company is the operating or management unit for business or industry, the farm is the operating or management unit in agriculture. At the management unit level, the farmer uses the resources at his disposal to maximize returns from his farm system as a whole.

Production systems research derives from the study of farm production economics, which remains the core concern of research in this field. But it has evolved to embrace the physical, biological, economic, and engineering problems of agricultural production and associated human and institutional problems.

Production systems research focuses on the organization and structure of farming. About 22 percent of the food and fiber in the United States is produced under some form of coordination, such as production contracts or vertical integration. In these cases, decisions made on the farm are greatly influenced by external forces.

Production systems research is concerned with the size of operations, costs, and returns of important types of farms. It includes analysis of return to labor, management, and capital; returns per $100 worth of feed fed; returns per acre of cropland; and returns by size of farms of the same type (7). Estimates of costs per unit of production are derived from descriptive data by type of farms or are obtained independently for major enterprises by location and size of farms. Such cost of production data are commonly used in appraising the adjustments farmers are likely to make in response to changing price-cost prospects and in production control programs (2,6).

Research in production economics deals with efficiency in the use of resources. Much work has been done on estimating production costs for farms that have similar kinds of resources and management but which differ in size. This research indicates that a one-man farm with a full complement of machines and equipment generally is more efficient than larger or smaller farms. That is, farms of this size are capable of producing at the least cost per unit of product.

This kind of research focuses on internal economies of scale (1,5). More research is needed to better describe the internal economies of scale in the production of various commodities.

Another area of research focuses on external economies of scale. These studies seek to measure the market power attained by large units in buying inputs below average prices through quantity discounts. in bypassing local dealers, and in assuming the role of retailers in the procurement of needed inputs. On the marketing side, these studies measure the above average prices available to large producers because of their ability to bypass local crop or livestock purchasers or agents in marketing their produce (4).

Much research has been done to examine the profitableness of alternative levels of resource use based on varying combinations of input and product prices. Examples of this kind of research include studies of the most profitable level of nitrogen application on corn with different combinations of prices of nitrogen and corn, the most profitable way to feed dairy cows by relating different combinations of feed and milk at different prices to the cows' ability to convert feed to mlik (3).

RESEARCH NEEDS

The following were identified as the important problems that require research related to production systems.

Rank Order		
		Resources
1		Identify practical energy-conserving alternatives for food production, including alternative cropping, harvesting, and storage systems.
2	SP	Investigate alternative multiple-crop management systems, such as wheat/soybeans, for maximum resource use.
2		Determine impact of failure to develop U.S. fertilizer technology based on using U.S. natural resources and feedstocks.
5	SP	Investigate the substitution of various forages for grain in order to produce beef of varying qualities.
5		Identify efficient systems to utilize crop and livestock wastes.

Rank Order		
		Resources (continued)
5		Study no-till and minimum-tillage systems with respect to energy, water, land, fertilizer, and other input requirements.
11	S	Analyze potential national, State, and local yield variations due to weather and publish estimates for each crop.
11		Determine effects of likely or possible shifts in crop production (i.e., substitution of soybeans for cotton, plant protein for animal protein) on supplies of necessary farm production inputs.
18	SP	Estimate effects on crop and livestock production of changes in availabilities and resource prices.
18		Develop new process machinery that will aid in improved conversion of grains into animal protein.
20		Prepare seasonal supply estimates of foreign-source materials critical to U.S. Agriculture.
		Management
4	SP	Determine the impact of taxes (income, inheritance, property, etc.) on production efficiency via changes in tenure arrangements, size of farming units, and choice of enterprises.
10	SP	Prepare better estimates of domestic and foreign demand and prospective supplies before farm production plans are made.
11	SP	Develop management strategies to help producers cope with increased price uncertainty.
15	SP	Establish basic budget data and ways of adapting them to individual farms early enough in the season to use in production planning.
a/	S	Develop management strategies that are effective on small farms.

a/ Included by delegates in research need area 11.2 Human Resources. It appeared in two problems with importance rankings of 9 and 15.

Rank Order		
		Management (continued)
	S	Describe the organization of agriculture with specific attention to viable full-time commercial units.
	S	Study management capabilities of farmers in relation to size of unit.
		New Technology
5	SP	Identify potential new technological developments and evaluate their impacts.
11	SP	Analyze the effect of new technology on the size of operation needed to produce efficiently.
	S	Evaluate the on-farm and off-farm impact of alternative technologies early in their development in order to guide allocation of funds for further development.
	S	Evaluate the potential effects of various prices on the profitability of technologies that are available but not used.
		Costs and Return
5		Develop cost/risk/benefit ratios showing impact of government regulations on cost of producing foods.
15		Develop and improve systems that will minimize the cost of pollution control.
17	SP	Compare costs and returns for specialized farming systems with those that can shift quickly from one product mix to another.
	S	Develop and maintain farm enterprise budget data systems for farms in major U.S. farming regions.
	S	Identify cost differences between the most and least efficient farm units, by crop or livestock type.
	S	Develop better ways to measure price elasticities and to identify the conditions where they apply.
	S	Update price and income elasticities.

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14.1 PUBLIC POLICY: DOMESTIC

Objective: To enable society to decide on public policies that will provide adequate supplies of food and reasonable prices for domestic and foreign markets, with due regard for conservation, environmental quality, and efficient use of natural resources.

SITUATION

In the United States, agricultural production, processing, distribution, and consumption proceed primarily through the private endeavors of individuals and businesses, yet each is significantly influenced by public policy. In the U.S. setting, this public policy emerges primarily from the understanding, desires, and efforts of the individual and group citizenry.

Since the development of commercial (market) agriculture in this Nation, public policy has been a prominent force shaping the pattern of land tenure of our farms, the structure of our markets, and the quality of our food. Historic policy legislation such as the Homestead Act, the Morrill Land Grant College Act, the Department of Agriculture Act (1862), the cooperative Federal-State research Hatch Act (1887), the cooperative Capper-Volstead Act (1922), and the Meat Inspection Act (1906) are strands in this thread of public concern and assistance.

Undergirding this country's approach is a commitment to initiate public policy only when unfettered, individual private actions seem unable to sufficiently protect the public interest. Whether it be a matter of conservation of land for future generations, development of the capacities of all rural citizens through education, stabilizing the prices of farm products in a gyrating market, or protecting the vitality of the rural community, citizens have worked through their government to solve a problem only when public policy seemed the reasonable alternative. With the growing complexity of all economic activity associated with scale of the efficient farm, with interdependencies of the import-production-distribution activities, and with a shrinking world characterized by increasing knowledge and interaction, the individual sometimes finds the problems too big to cope with alone.

Yet, the farmer, consumer, agribusiness manager, or community official--indeed, every citizen--can understand these complex problems and decide on reasonable policies only when dependable, complete facts are at hand and when the benefits and costs of alternatives have been adequately assessed.

In the past, research on public policy has provided information on and evaluation of the benefits and costs of alternative policies and programs. In recent years, food prices and farmer income have been major issues in public policy discussion and research (1,2,4), but marketing aspects of agricultural and land retirement programs have also been of concern (3,5). As new research methods and procedures have been developed in the field of economics, they have been applied in the analysis of policy problems (3).

If this research enterprise is to serve the public in providing current, relevant, and useful input into the stream of public policymaking, then it must be sustained and its agenda must be set with sensitivity to both the past and present economic scene. Some of the problems to be confronted in future public policy decisions are already taking shape. In view of future national and world needs for food, the needs for further research on public policy are either already clear or are beginning to crystallize.

RESEARCH NEEDS

The following were identified as the important problems that require research related to public policy: domestic.

Rank
Order

Government Programs and Policies

1 SP Develop strategies and techniques to accommodate American food production and processing practices to the impending exhaustion of fossil fuel supplies.

2 Determine the effects of tax, price, antitrust, land tenure regulations, and cooperative marketing policies on the type of economic organization of agriculture that we will have in this country, e.g., a dispersed, competitive agriculture, an agriculture concentrated in the hands of nonfarm corporate firms; or a government-controlled agriculture.

3 Determine whether the "target price" concept is a constructive farm policy tool in terms of effects on production, budgeting costs, and international trade relations.

4 SP Evaluate transportation systems to determine the need for future facilities and their impact on energy use as well as delivery capability under varying demands.

Rank Order		
		Government Programs and Policies (continued)
4		Evaluate agricultural research policy to meet long-term food and fiber needs; to provide support for basic and applied research, combine short-term, local needs with long-term, national needs; and to determine public and private roles, manpower, and institutional requirements.
4	SP	Develop information on existing land resources, the need for protection of agricultural land, and the cost/benefit of alternative policies and programs to effectively guide and regulate land use.
4		Evaluate price and income support programs for agriculture: impacts on producers, consumers, taxpayers, others; relation to foreign trade; efficiency of agricultural production; operational guidelines.
8	SP	Evaluate the potential of intermediate and long-run governmental assurances on prices and income, as a means of stimulating agricultural output.
12		Determine the impact of State trading by other nations on U.S. agriculture and pros and cons of U.S. trading boards.
12		Evaluate the relationships between cash and futures markets, the structure of trading on futures markets, policy instruments to prevent the manipulation of futures where there is no viable cash market, and conditions necessary to support the cash market in its allocative role.
16	SP	Determine the effects of alternative methods of taxation on land use and food production.
20		Evaluate the effects of price controls on food and agriculture: producer and consumer prices; processors' and distributors' margins; production; distribution of product to users; other market behavior; administrative feasibility.
	S	Investigate the implications of, and means of, improving existing farm legislation.
	S	Evaluate alternative means of managing crop supplies, such as management of inputs or production factors other than land.

Rank Order

Government Programs and Policies (continued)

S — Find ways to encourage more food production by small farmers, part-time farmers, and underemployed rural people.

S — Estimate the costs of commodity programs in relation to costs of food.

Reserves

10 SP — Evaluate reserve stock policy in regard to the relationships that market price functions (i.e., encouraging substitution, stimulating consumption shifts, and prompting production adjustments) have to reserve stock quantities, carryover levels, and the width of a price band for free market operations insulated from governmental actions to acquire or release stocks.

10 — Evaluate different purposes of reserve stocks designed to soften the extremes of adjustments in commercial markets and reserves acquired as a tool for increasing the reliability of food aid.

19 S — Evaluate the consequences to farmers, consumers, and taxpayers of alternative policies for acquiring and releasing stocks.

S — Evaluate the consequences to farmers, consumers, and taxpayers of alternative means of ownership and control of stocks.

S — Estimate the costs of alternative reserve programs.

Public Information

16 S — Develop information on ways to participate in the formulation of public policy for agriculture and the food system.

S — Estimate the requirements for grains in disaster-prone areas and its potential impact on U.S. food production.

Consumer Needs and the Environment

12 — Search for feasible alternatives or modifications to those agricultural and food processing practices which adversely affect environmental quality.

Rank
Order

Consumer Needs and the Environment (continued)

12 Actively support the development of ecologically rational pest control methods to replace current ecologically destructive practices.

16 SP Evaluate and improve availability, conservation, and allocation procedures of energy sources for the production of food and fiber with due consideration to the distribution in different geographical areas.

S Develop information on the total agricultural industry needs for public monitoring of crucial supply, demand, and trade variables.

S Evaluate the nutritional impact of alternative food assistance programs on recipients.

Food Assistance

9 Reexamine present domestic food aid programs to identify feasible and more effective ways to eliminate involuntary undernutrition either by modification of present programs or by substitution of different approaches.

S Analyze and compare the effects of (1) assistance restricted to certain categories of consumers through food stamps and direct food distribution and (2) an income assistance program without such restrictions.

S Determine costs and benefits of alternative ways of administering the food stamp program.

S Evaluate food policy implications of recent shifts in consumer demands.

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14.2 PUBLIC POLICY: INTERNATIONAL

Objective: To support the decisionmaking process by the public and the U.S. government by assessing effects of alternative policies of various nations on prices, farm income support, resource allocation, trade, exports, food aid, technical assistance, reserves, etc.--including the effects of interacting policies in a world environment.

SITUATION

Public policies and programs of the United States and other nations are believed to have major effects on such variables as food production and consumption, international agricultural trade, economic growth, and agricultural income and employment. However, we have done very little to devise methods of assessing possible and likely effects of international and national policy decisions before they are made.

Up to now, most U.S. research on possible effects of agricultural policies seems to have been concentrated mainly on domestic effects of domestic policies. In our newer environment, in which the U.S. agricultural sector is more closely linked than ever before to the world economy, we need strong emphasis on assessing interlocking effects of agricultural and trade policies in many nations.

In general, past international agricultural policy research has been either secondary to economic projections work, or else mainly descriptive of existing policy with some notion, more or less detailed, of how policy might change. In policy research related to projections, the main interest has been in constructing a model, usually a simultaneous equations model that yields a point projection for some future year. The emphasis has been on the "constant policies" assumption, in which the current structure or trends are projected. However, "alternative policies" assumptions can be grafted on to the basic model by changing certain key coefficients to represent imagined alternatives. Alternative projected values for the projected year are thus derived (1,2,3,4,5,6,7,8,9).

In descriptive policy research, the main interest has been in cataloging the policies of many countries or in detailing the policies of a single country and trying to sense what the policyforming forces are and where paths into the future may lie (10,11,12,13,14,15,16).

In this work, effects are usually described qualitatively rather than quantitatively, except as desired effects may be expressed as planning targets. No quantitative methods are used to determine whether proposed or envisioned policy changes may or are likely to yield the targeted quantities.

Neither alternative projections nor policy effect descriptions are capable of dealing with the sequential interaction of policy moves over time by different, rival, or adversary decisionmakers--as occurs in international policymaking. Also, neither approach can assess the impact of such uncertainties as weather on the decisions themselves and the variables meant to be affected by these decisions. Furthermore, projection-related and descriptive work generally do not incorporate theories or processs from disciplines other than economics in research or public policy formulation. In a world where agricultural policy moves interact and can be affected by, for instance, weather, it is unrealistic to assume interaction away. Consequently, policy research on international aspects of agriculture is still in its infancy even though it is widely acknowledged that the international effects of agricultural policy moves are now greater than ever.

RESEARCH NEEDS

The following were identified as the important problems that require research related to public policy: international.

Rank
Order

Reserves

1 SP Evaluate alternative world food reserve policies designed to achieve varying degrees of price and supply stability.

4 Evaluate international dimensions of reserve stock policies, including burden sharing, nature of commitments, and distinctions between food aid needs and commercial requirements.

13 SP Determine the probability of world surplus or deficiency in capacity to supply food and feed grains.

16 Analyze the relationship betwenn governmental distortions in agricultural trade and production, whether from import, domestic, or export policies and the size of reserves needed to accommodate supply fluctuations in world grains and oilseeds.

Rank
Order

Reserves (continued)

S Analyze the relation between food reserve systems, stabilization of the world monetary supply and price levels.

Foreign Assistance

1 SP Analyze the implications of alternative U.S. foreign technical and food assistance on income level and distribution and on employment in recipient countries.

6 SP Estimate the impact of U.S. foreign food aid upon domestic farm and food prices and upon the farm and food sectors of recipient countries.

6 S Evaluate the effects in recipient nations on employment and income distribution of assistance to increase their food production.

6 Search for substitute modes of foreign assistance which will have the long-term effect of decreasing future aid requirements of recipient countries, rather than having the long-term effect of maintaining or increasing those requirements.

11 Ascertain types of education and training suitable in particular situations for students and trainees for LDC's.

19 S Describe the impacts on farmers, consumers, taxpayers, processors, distributors, and other U.S. groups of different scales of food aid to other countries.

a/ S Determine the probabilities of drought, flood, or other natural disasters in various regions of the world in order to prepare contingency aid plans.

S Determine the technical and financial assistance required by developing countries most severely affected by high energy and fertilizer prices.

Trade and Monetary Policy

4 Determine policies and strategies for association of farmers, through freely constituted representative bodies such as cooperatives and farm organizations, to engage in foreign trade and to formulate and implement agricultural and rural policy in developing countries.

Rank Order		
		Trade and Monetary Policy (continued)
6		Examine the impact of U.S. production, import, and export policies on agricultural trade of other nations and the effect of the production, import, and export policies of other nations on U.S. agricultural trade.
6		Analyze the impact of export controls on the domestic economy, on importing nations, and on international political, and commercial relations.
11	SP	Evaluate the effects of exporting countries' agricultural trade policies on the demand for U.S. farm products with special attention to identifying and assessing the effects of export subsidy policies.
13		Evaluate the systems of incentives and inspection and grading practices for means of improving the quality of food and fiber imports and exports as received by final recipients.
16	SP	Determine alternative types of international commodity agreements and their advantages and disadvantages for the United States.
18	S	Monitor and project changes in world demand and supply in response to foreign exchange rates and other international financial factors.
19	S	Analyze the cost and benefits of governmental export boards and compare to effects of enterprise marketing system, including effects on investment, innovation, and cost of services over time.
	S	Evaluate the impact on the developing countries' agricultural trade of the preference system authorized by the Trade Act of 1974.
	S	Assess the effects of Soviet and Eastern European grain importing policies on world supply and price stability.
	S	Analyze effects of importing countries' agricultural trade policies on the demand for U.S. farm products.

Rank Order		
		Trade and Monetary Policy (continued)
	S	Investigate the probable consequences on U.S. agriculture of further liberalization of trade.
	S	Measure the impact of nontariff trade barriers applied by foreign countries against agricultural imports.
	S	Evaluate impacts of varying rates of general worldwide inflation on farm product markets.
	S	Evaluate alternative policies to promote agricultural exports.
		Research Policy
b/	S	Assess the economic consequences of public investment in agricultural research and technology; determine the implications for future public policy under alternative sector situations.
		General Policy
1		Establish alternative scenerios of long-range (beyond 1985) future resource use and production alternatives in light of various projections of population growth, development of new technology, potential of exhausted fossil fuels and other known energy supplies including scarcities brought about by cartels.
13		Analyze the implications upon agricultural production, cost of food, and environmental quality of energy from long-range alternative sources to our present fossil fuels, increasingly heavily dependent upon international trade.
	S	Identify and evaluate current trends in environmental factors that determine world food production such as climate and weather.

a/ Included by delegates in research need area 3.3 Weather and Climate with an importance rank of 11.

b/ Included by delegates in research need area 11.2 Social Institutions with an importance rank of 2.

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14.3 FINANCE

Objective: To reduce the cost of financial management in production and marketing; to lower financial barriers to economic opportunity in production and marketing; and to increase the equality of access to financial markets.

SITUATION

Capital formation and financing have been major contributors to the expansion of the world's agricultural capacity. A recent report by the Organization of Economic Cooperation and Development reviews extensively factors that affect capital formation in agriculture, including governmental efforts and individual incentives for capital investments (4). This study indicates that both aggregate and individual use of capital has been growing at a rate faster than agricultural output in current as well as constant price terms. For instance, over a 10-year period starting in the late 1950's, gross investments in buildings, machinery, and land improvements increased from about 14 percent to 19 percent of gross output--reflecting the increasing capital intensity of agricultural production.

Reduced cost of financial management and capital accumulation is closely associated with expansion of agricultural productivity (3). In developed economies, a rich financial environment provides the agricultural producer with methods of insuring against major production risks and of supplementing his internal financial resources with external ones to finance production and marketing programs (4). For noninsurable risks, it provides him with options in inventory management: crop, livestock, and financial. In financial inventories, the options can be further divided: cash, cash substitutes, and even credit. Credit, like cash, can be held in reserve to meet contingencies (1).

In the United States, as in other developed countries, agriculture has become increasingly vulnerable to market risks. Off-farm inputs have increased as a percent of all inputs (4). The trend to fewer and larger farms has increased the use of external sources of finance to expand either extensively or intensively. Although in many countries a greater part of capital needs are still financed internally, capital from external sources will continue to increase relative to the total. In 1974, 15 percent of the total cash uses of funds in U.S. agriculture was supplied from loan sources as compared to 5 percent in 1960 (5). Projections to 1980 indicate that this level

of external financing is likely to increase. By 1980, the amount of debt outstanding could be double that in 1974. This would result in an overall debt to asset ratio for U.S. agriculture of nearly 24 percent in 1980 as compared to nearly 17 percent in 1974.

Many interesting alternatives are being tried regarding leasing and partnership arrangements as well as varied forms of corporate structure. In contrast with debt instruments, these alternatives create new and disbursed equity interests in agriculture and redistribute the incidence of risk. It is reasonable to suppose that the focus of decisionmaking also is modified. The same is true of the development of marketing and/or production contracts that have altered commodity markets.

Risks have recently been increased by the internationalization of markets for agricultural commodities and the reduction of crop inventories. Although demand relations may be modified to reduce price response to variations in supply, the demand relations are themselves subject to greater fluctuations, especially in light of reduced inventories. Variations in values of foreign exchange also increase market risks, adding to the costs of risk management. Such costs are straining capital and management resources in the United States and in other developed countries. They are testing the innovations just referred to and are creating demands for new methods of managing risks. Responses can be observed, for instance, in expanded participation in commodity futures markets. A large part of the response must be in finance: financial management on farms and innovations in financial markets.

An essential element in the transfer of resources into food production will be a financial system that fosters the most productive use of resources and contributes to increasing productivity over time. This will involve elements of finance research concerned with the microeconomics of individual farms as well as elements of macrofinance that involve national economic policies affecting capital formation, the functioning of financial markets in rural areas, and the flow of funds between agriculture and other sectors (2).

RESEARCH NEEDS

The following were identified as the important problems that require research related to finance.

Rank Order		
		Demand and Supply
1		Study the problem of intergenerational transfer of farm property and the effects of particular tax policies--such as estate and inheritance taxes--upon this process as a means of maintaining the family farm.
2		Evaluate the effects of tax policies on the financing of farm capital requirements and the structure of agriculture.
3		Analyze the equity of existing tax policy as applied to farms of different types (i.e., structure) and sizes.
3	S	Measure the rate of return by categories such as size and type of farm.
5		Evaluate means for new producers to enter farming, such as permanent debt and other financing arrangements.
6	SP	Assess aggregate short-term and intermediate adjustments in farm capital that are required in periods of price and cost uncertainty, as recently experienced in the cotton and livestock sectors.
6	SP	Evaluate the necessary level of public funding for adequate research in agricultural production and marketing, domestic and international agricultural policies as related to cost/benefit ratios to agriculture and the economy.
8	SP	Identify the factors that encourage or discourage flows of capital into the agricultural sector.
8		Evaluate the impact of emergency credit legislation in periods of financial disaster.
8		Investigate efficiency and equity effects of real estate, income, and other types of taxes on farm firms and on other taxpayers in rural areas.
12		Evaluate the financial advantages of present and proposed tax loopholes on each sector of taxpayers particularly producers, processors, and consumers.
14		Identify the links between concentrations in the financial sector and the growth of concentrations in the agricultural sector.

Rank Order		
		Demand and Supply (continued)
15		Determine the relative benefits of low-interest development loans and fast tax write-offs as a tool for the expansion of agricultural production.
15		Devise equitable methods to generate additional income for those who cannot now purchase needed amounts of agricultural products.
17		Evaluate policy for financing consumer organizations engaged in business activities related to the food industry.
20		Investigate financing of foreign purchases of land, food production, and processing capacity of the U.S.; investigate financing of U.S. purchases of land, food production, and processing capacity abroad.
	S	Evaluate the availability of capital to meet economically feasible requests for productive purposes that otherwise would be impossible to meet through a farm unit's own means.
	S	Determine the relationship between sources of funds and uses of funds, how cash flows of capital are financed, factors that affect the substitution of current income for loans, and other factors that influence demand and supply of capital.
	S	Identify factors that contribute to misallocation of equity or debt capital.
		Financial Markets
8	SP	Evaluate the impact that innovations in securing capital funds (incorporation, integration, contracting, leasing etc.) may have on farm ownership and debt patterns.
13	SP	Evaluate the implications of government subsidization of agricultural credit such as FHA, REA, and the credit phases of CCC.
17	SP	Evaluate the impacts of government agencies that monitor and regulate private credit institutions serving agriculture--the FCA, commercial banks, etc.

Rank
Order

Financial Markets (continued)

17 SP Investigate the linkage between financial markets serving agriculture and those which serve other local or national users of money.

S Develop alternatives by which credit management assistance could be provided to agricultural firms and cooperatives.

S Identify and evaluate the barriers that affect entry into and exit from the agricultural sector by new and older individuals and the implications for ownership and use of major resources.

S Investigate the relationships between commodity markets and financial markets including agricultural terms of trade and the evolution of techniques for managing commodity exchange.

S Monitor the economic and financial environment in which agricultural decisionmakers operate.

Data Systems

S Provide information about sources and flows of equity capital into and out of agriculture.

S Estimate gross and net flows of funds into agriculture.

S Develop procedures for monitoring interest rates by types of lenders.

S Provide information about flows of long, intermediate, and short-term loans from individuals, merchants, and dealers.

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15.1 INTERNATIONAL DEVELOPMENT: FOOD PRODUCTION TECHNOLOGIES AND RESOURCE MANAGEMENT

Objective: To increase production of food and improve resource management capabilities in developing countries, with special concern for small limited-resource farmers.

SITUATION

The current and increasingly critical food problems are primarily in the developing countries. Recent projections of food production and requirements show large and growing deficits in the developing countries (1,3,4).

Taking the only reasonable view--that food should be provided for the peoples of developing countries--the plausible alternatives are either massive food aid or help to the developing countries in increasing food production through a combination of research (much of it necessarily in the developing countries), training, investment in delivery systems for nontraditional inputs, and investment for land development including water, marketing, transportation, and storage systems.

While the United States and a few other developed countries can and must assist by producing and transferring food to needy areas, this is of a palliative nature. In large measure, the developing countries themselves must produce the additional food required.

Increased agricultural production in the developing countries will require a higher level and continuing input of technology resulting from research. While the costs of such an effort loom large, the benefits can be substantial. T. W. Schultz has shown that social rates of return on wheat and corn research have been on the order of 700-800 percent per year (4). More recently, Evenson and Kislev have shown that the rates of return on agricultural research are generally higher than returns on other forms of public investment (2). Research funds to produce new technology in developing countries has been, and is, only a small portion of that spent in developed countries.

All agricultural research wherever performed has the potential for being useful in the developing countries. But agricultural research performed in the United States and other developed countries will not be useful unless a systematic effort is made to transfer and adapt research results to conditions in the developing countries.

For crops grown extensively in developed countries--in particular wheat, rice, maize, sorghum, and soybeans--transfer of basic work and promising specialized strains is practical, and scientists in developed countries have expertise that can be applicable for research in the developing countries. For the tropical crops, most of the research must be done locally in the developing countries.

Agricultural research systems in the developing countries can be strengthened by linking them to appropriate research institutions in the developed countries and to the international agricultural research institutes supported by the Consultative Group on International Agricultural Research (CGIAR). These institutes have made major contributions by developing high-yielding varieties of dwarf wheats and paddy rice for irrigated areas. Critical to the concept of linkages is the feedback of research results developed by scientists in international centers and national research organizations to agricultural research scientists in the United States and other developed countries.

The United States is in a particularly strong position to help strengthen agricultural research in the developing countries. It is a major supporter of the international agricultural research centers. It has the world's greatest national agricultural research resource base which already has much experience in the agriculture of the developing countries. This U.S. resource base needs to be tapped much more effectively in order to help the developing countries acquire needed agricultural technology.

Of overriding importance to developing countries is research to increase supplies of crop and livestock products and to enable them to manage their production resources more effectively.

The need for plants that give higher yields of a superior product for any given level of inputs is a problem of common interest to the United States and to the developing countries. It is increasingly recognized that further breakthroughs in plant productivity will require greater attention to more basic or fundamental research on plant processes. Thus, research on basic problems of plant growth and reproduction carried out (or planned to be carried out) by U.S. agricultural research scientists is particularly critical to improving food production capabilities in the developing countries. (See Area 16 on this subject). This research should be linked deliberately with a small but significant amount to be done in the developing countries themselves.

<u>Cereals</u> provide the mainstay of the diet of most developing countries, especially for the poor. Because cereals supply an average of 53 percent of the energy and nearly half of the protein requirement,

research to increase their yield and protein content is of crucial importance. Despite the real successes in increasing wheat and rice output, improvements in other cereals has been less spectacular, and cereal production in developing countries has barely kept pace with population and income growth during recent years. Experience in the populous countries of Asia and in the West African Sahel in the past few years shows how fragile is the base on which these critical food supplies rest. In many developing countries, failure to increase production rapidly enough to meet domestic demand has led to increased dependence on imports which has drained foreign exchange required for social and economic development.

In the past, increased output of cereals was achieved by expanding the cultivated area. Although certain countries have reserves of good land that can be brought into production, many are already pressing up against the limits of their land resources. Thus, it becomes imperative to increase yields and crop intensities as the major source of future growth. (See Area 4.1-5: Cereals.)

Food legumes are important dietary staples in the developing countries. They are a source of protein and improve the overall quality of protein in the diet by balancing the low-lysine protein of the cereals. They also are potential sources of simulated milk and meat products. Soybeans already are being developed industrially for this purpose. (See Area 5.1: Soybeans.)

There are special difficulties in improving productivity in the food legumes which make international support for research particularly necessary. (See 16.0:Basic Problems of Plant Growth and Reproduction.) Yields and prices paid to farmers for food legumes are often low, making them less attractive commercially than the cereals. Little is known about their inherent yield potential, though careful management has brought moderate yields at experiment stations in India and the United States.

While there are numerous pest and disease problems of varying location specificity for the food legumes, there also appear to be physiological and morphological problems that currently impose a low ceiling on yields even when pest and disease control measures are highly efficient. These include indeterminate flowering habit, high rate of flower drop, photosynthetic inefficiency, excessive vegetative growth, and residual toxicity to subsequent crops.

Starchy foods make up a third major group of food crops which should be accorded high priority in the developing countries. These crops include roots and tubers. Despite their nutritional drawbacks, they are of great dietary importance in the developing world. They have a potential for producing an enormous output of energy per hectare,

and their yield, nutritional potential, and range of adaptation appear to be capable of improvement. Yet, they have received much less concentrated research attention than the cereals, since, in the developed countries; only the potato is of general significance.

Livestock also provide opportunities for increasing food supplies. While there are greater constraints on a rapid increase of ruminant production than for pigs and poultry, the use of forages by ruminants provides a great potential for better resource utilization which conflicts only to a limited extent with requirements for land for direct production of human food. The work of CIAT on developing beef production in the Llanos of Latin America suggests that there are major untapped opportunities there and in related areas such as the Campo Cerrado of Brazil. Moreover, ruminants are of dominant social and economic significance in some of the poorer and most backward countries that have little scope for other agricultural development and where knowledge acquired in developed countries cannot be transfered easily. There are possibilities for expanding both beef and milk production, and the latter may offer a new cash activity to small farmers as well as having important potential for the improvement of nutrition.

Where feedstuffs are available over and above the needs for direct human consumption, pig and poultry production can be increased relatively easily by sophisticated, capital-intensive methods provided that rigorous control of disease can be achieved and entrepreneurship and sound managerial ability are available. Neglected opportunities also exist for improving small-scale pig and poultry husbandry by labor-intensive methods, the application of known methods of disease control, better feeding, and effective management of small-scale production but these will not require extensive research. (See 8.1-3: Forage, Pasture, and Range and Areas 9.1-4: Beef, Pork, Lamb and Mutton, and Other Animal Products.)

Aquatic Foods--One other highly promising means of increasing supplies of protein lies in aquatic foods. New and more scientific methods of obtaining fish and other aquatic creatures are evolving rapidly, but so far they do not appear to have had as great an impact on domestic food (or feed) supplies in developing countries as they have had in increasing export earnings. (See Area 10.3: Aquatic Food Sources.)

Factor Oriented Research

In the developing countries, more research and development are particularly needed on several key problems. These include management of land and water resources, fertilizer resources, crop protection, environmental constraints, and the interface of energy use and agricultural production.

Water use and management must be related to the crop-mix rather than to the individual crop. Management of soils in the tropics and subtropics calls for a technology that is not directly transferable from work done in the temperature zones. Fertilizer and pesticide residues contributing to environmental pollution result from the totality of the farm operation and not from just one enterprise. The introduction of small-scale livestock often implies a major revision of an established system. Multiple cropping depending on high output per annum, involves radically different management and plant breeding and cultural concepts than systems that depend principally on high yield per individual crop. Inadequate survey and exploration of surface and subsurface water resources combined with insufficient research on soil/plant/water relationships is frequently a serious obstacle to sound design, good water management, and the development of optimum production systems in irrigated areas.

RESEARCH NEEDS

The following were identified as the important problems that require research related to food production technologies and resource management in international development.

Rank
Order

1 SP Develop high-yielding varieties of important food legumes and other vegetables (including dry beans, soybeans, cowpeas, pigeonpeas, chickpeas, peanuts, lentils, and broadbeans) with high level of genetic resistance to insect and disease problems giving physiological and morphological constraints that limit yield of this group of food crops (including indeterminate flowering, rate of flower drop, and photosynthetic efficiency), attention to soybean varieties in the tropics and subtropics, and attention to nutritional content and naturally occurring toxicants.

2 SP Develop high-yielding varieties of cereals (including wheat, maize, rice, sorghum, millet, and barley) over a wide range of environmental conditions including resistance to insect pests, diseases, and unfavorable soil conditions, with attention to nutritional content and naturally occurring toxicants.

3 SP Develop improved soil and water management technology, particularly in relation to food production in the developing tropical countries.

Rank Order		
3	SP	Develop alternative or improved technologies for supply of plant nutrients including more effective and broadbased biological fixation of nitrogen and more appropriate clemical fertilizer technology for tropical soils and climates.
5	SP	Develop high-yielding varieties of important starch food staples (including potatoes, sweet potatoes, cassava, and yams) with attention to nutritional quality, disease and insect resistance, nutritional content, and naturally occurring toxicants.
5		Develop procedures to minimize high-energy technology inputs while increasing crop, livestock, and poultry production through new genetic and management programs.
7	SP	Develop improved farming systems with emphasis on the small farmer (may include a series or a combination of crops along with livestock).
8	SP	Develop low-cost, low-risk inputs and integrated methods of crop protection against insect pests and diseases.
9	SP	Develop methods of soil conservation appropriate to the tropics.
9	SP	Develop improved ruminant livestock production systems by improving production of feed including pasture, forage, and range management; control of important diseases; and identification and evaluation of socioeconomic constraints to increase livestock production.
11		Develop high-yielding varieties of vegetables and fruits as important sources of vitamins, minerals, and other essential dietary nutrients not provided by cereals, legumes, and starchy roots and tubers.
12	S	Develop improved technology for production of aquatic sources of food.
12		Identify likely priorities and trade-offs between yield-increasing research on each of the major crops in terms of estimates of unexploited potential for yield increases via varietal research.

Rank Order		
14	S	Appraise the physical, chemical, and biological properties of soils.
15	SP	Collect information on seasonal evaporation rates (averages and probabilities) and on rainfall patterns for use in planning water management and cropping cycles.
16	SP	Investigate the use of power in tropical agriculture.
17	SP	Develop appropriate mechanization technology for food production in the developing countries.
17		Develop information leading to increased production and utilization of breast milk.
17		Evaluate technological impacts on food output, such as the problems of environmental contamination from industrial waste.
20		Develop research on the adoption of transfer of agricultural and industrial technology into the socioeconomic and cultural setting of developing countries. This includes research on the sociocultural, behavioral, and environmental influences that determine or alter the utilization of food resources.
	S	Conduct long-term evaluations of the effect of land use on stream flow in catchment areas.

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Objective: To improve the quality of food to ensure adequate nutrition and to improve the means of food processing, storage, preservation, and distribution in developing countries.

SITUATION

Food Quality--Food supplies alone do not guarantee man's nutritional requirements. Even in developed countries with ample supplies, serious health problems are caused by the wrong kinds and amounts of food. In the developing countries, the problem of insufficient food supplies is compounded by the problems of inferior food quality and malnutrition.

Millions of people in the world suffer from malnutrition. FAO has concluded that out of 97 developing countries, 57 were deficient in food energies in 1970. FAO estimates that close to 460 million persons in the world are malnourished (1).

Malnutrition is primarily a function of poverty. Most of the world's malnourished live in the developing countries--in the Near East, Asia, and Africa. Between one-fifth and nearly one-third of all people living in these areas have an insufficient food supply, compared with only 3 percent in the developed countries (2).

In many developing countries, women and children are the most vulnerable to malnutrition. Children also are affected by their inability to ingest sufficient protein when starchy foods are the main staples. As many as half of the young children in the developing countries may suffer in varying degrees from inadequate nutrition (1).

Although malnutrition can result when the intake of any essential food element is too low, most of the world's underfed suffer primarily from insufficient caloric intake, which for the developing countries is clearly linked to low incomes (see Area 15.3). Poverty, however, will be extremely difficult for developing countries to overcome rapidly. In the meantime, a number of programs can be helpful, such as special food distribution programs, improvement of the nutritional value of basic crops, and fortification of food staples.

Nutrition Education--Nutrition research must be complemented with education if available nutrients are to be put to use (see Area 1.4). Traditional ways of preparing food may waste significant amounts of

protein and require excessive amounts of time and energy. Social attitudes may prevent other valuable foods from being used (see Area 1.3).

Finding improved ways of feeding pregnant women, lactating mothers, children, and the ill also is a function of education. Food technologists must discover new ways to prepare food that meet the cultural preferences of people as well as raise the nutritional standards of the final products.

Food Distribution--While it is urgent to increase food production in the developing countries, the problem of food distribution is equally critical. In many developing countries, malnutrition can be viewed as a consequence of the maldistribution of food as well as of low income and unequal distribution of income.

Farmers will not use improved production technologies and consumers will not benefit from more and better quality food unless there is a reliable marketing system. Successful marketing requires an effective system to assemble, store, process, and transport farm products to domestic and foreign consumers. Population growth, migration to cities, rising incomes, and better education about what constitutes good nutrition make it essential that the marketing system function effectively.

In developing countries, product marketing systems range from simple local ones that link producers to local consumers to complex ones that process commodities and move them thousands of miles or store them in highly sophisticated ways. Some of the more critical factors adversely affecting these marketing systems are inadequate and costly transport, inadequate storage, taxation, particularly of export crops, and restrictions on trade across national boundaries. (Some of these aspects of marketing are discussed in Area 15.3.)

RESEARCH NEEDS

The following were identified as the important problems that require research related to food quality and distribution in international development.

Rank
Order

1 SP Determine standards for what constitutes a balanced diet by major age groups in developing regions and countries, taking into account energy, vitamin, mineral, and protein requirement.

Rank Order		
2	SP	Develop information on the income-consumption patterns among family members of both rural and urban households.
2	SP	Devise low-cost techniques for farm or village storage of all commodities.
2	SP	Assess losses and waste of food incurred in harvesting, marketing, and household preparation.
2		Develop simple, low-cost methods for fortification of foods ranging from the industrial level to the village level.
2		Clarify the relative importance of deficiencies of protein, of calories, and of other nutrients as these influence the health of the preschool child and determine programs for fulfilling these needs.
7	SP	Appraise health problems resulting from malnutrition and devise strategies to overcome them.
7	SP	Determine the biological availabilities of nutrients in major staple foods of developing countries and regions.
9	SP	Conduct research on nutrient requirements of man and the biological availability of nutrients from foods: nutrients inherent in the foodstuffs as well as nutrients added in the processing or industrial improvement of the food.
10	S	Develop standards and grades for major crop and livestock products including consideration of impacts on farmers' incentives.
10		Improve techniques for estimating accurately the production and storage losses caused by pests (including rodents and other animals).
10		Conduct research to develop improved techniques for more effective education and training of professionals in nutrition and foods (including health, agricultural, and educational professionals), as well as developing effective, relevant, educational techniques for school and community-based programs.

Rank Order	
10	Conduct research on nutrient composition of foods in the forms they are consumed, including developing a usable data bank, with attention to nutritional effects of storage, preservation, and distribution systems.
14 SP	Determine methods to enhance or protect food quality from farm to consumers.
14	Develop a research program to develop nutritional standards for different countries and different climates.
14	Research the methods and means of communicating the existing knowledge of nutrition to adults and children in the developing countries.
14	Develop (in the U.S. initially) a high nutritious, low-cost weaning food to meet immediate requirements in the developing countries; extend research to development of a weaning food using food grown in quantity in developing countries so that production can eventually take place in those countries.
18	Develop methodologies (models) for the integration of the following components at the grassroots or village level: (a) improve the quality of food, (b) insure adequate nutrition, and (c) improve distribution.
19 SP	Develop appropriate processing and preservation technology for seasonal and perishable foods.
19 SP	Develop low-cost systems for rainy season harvesting to minimize losses and preserve quality.
19	Develop and implement specific nutritional and food measures to meet severe or acute public health nutritional needs (e.g., vitamin A deficiency and preventable blindness, iodine deficiency goiter, anemia due to iron or folic acid deficiency, protein-calorie malnutrition in infants).
S	Provide a continuing source of research information and work in progress from public and private research organizations to developing country research organizations and relevant government agencies.

Rank
Order

S Make U.S. personnel and techniques for conducting nutrition surveys available through appropriate institutional linkages.

S Evaluate the importance of social attitudes on the use and consumption of nontraditional food commodities (e.g., vegetables in the diets of subsistence cereals producers).

S Evaluate and devise nutrition education programs that are appropriate to varying family systems and cultural groups.

S Develop storage and distribution systems for nontraditional, more nutritious foods.

S Develop methods for motivating people in developing countries to use improved new foods or preparation processes.

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15.3 INTERNATIONAL DEVELOPMENT: ECONOMIC, POLITICAL, AND INSTITUTIONAL ASPECTS OF TECHNOLOGY AND RESEARCH

Objective: To develop economic, political, and institutional arrangements that will contribute to increasing and improving food supplies in developing countries and facilitate the organization of research resources and transfer of technology.

SITUATION

Of necessity, expanding food production and enhancing food quality will require the resolution of complex physical, biological, and technological problems. Equally critical are the economic, political, and institutional arrangements that affect man's ability to achieve adequate living standards and a satisfying life. These arrangements impact on the ability of people to motivate and organize themselves to develop policies and programs and attitudes to overcome obstacles to agricultural development. The challenge is directed to local, national, and international political leaders; to social scientists, researchers, and educators at all levels; to business executives and labor leaders; and to farmers and craftsmen, because they in particular must take the initiative in seeking political, economic, and institutional change.

Establishment of terms of trade and credit between developing countries and modern industrial nations is required for sustained development. Developing countries cannot achieve agricultural emancipation and modernization without effectively planned and organized technical assistance, development loans, internationally negotiated terms of import and export controls, and price policies specifically adapted to their development needs. This will require improved functioning of the United Nations Organization, the World Bank, the International Monetary Fund, bilateral foreign aid programs, and foreign trade policies.

The United States carries a heavy responsibility, not only because of our predominant economic size among the industrial nations, but also because of our historic commitment to a democratic social order. We have barely realized the awesome weight of this responsibility. To live up to it, we need to give much more thought, understanding, and genuine cooperation to the newly developing world than we have in the past.

Income and Equity

For centuries, most small farmers have been living in an environment of severe poverty. Even developing countries that have experienced significant growth rates in gross national product are still burdened with problems of income distribution. A recent study of 44 developing nations showed an average of only 26 percent of all national income going to the poorest three-fifths of the people, while the richest one-fifth received 56 percent.

International Trade and Commodity Agreements

Recent trends and projections to 1985 indicate that the volume of international trade in agricultural products will continue to increase. Future trade patterns and policies hold important implications for both the United States and other developed countries and the developing countries. Rapid population growth will tax the production capacity of less developed regions to meet their own consumption requirements. In many developing nations the ability to buy food will lag behind nutritional requirements, increasing the need for special assistance from the developed world.

Increased energy prices reduce the ability of most developing countries to buy food commodities in world markets. About 40 countries with 900 million people in Africa, Asia, and Latin America will be most adversely affected. Food production from the recently introduced high-yielding crops requiring chemical fertilizers and pesticides may be impaired because many developing countries lack the resources to buy or produce these inputs at current market prices.

The developing countries will be most vulnerable to yearly production shortfalls for both food and export crops. Thus, the issues of adequate world food reserves and international commodity agreements take on special significance.

Agricultural Policies

Many developing countries have policies that limit incentives for their farmers to produce more. Several kinds of policies that are widely practiced, although in different degrees, in a number of developing countries have important influences on how much food is produced in these countries and how much is consumed and traded internationally.

In countries where agricultural or food exports are one of the few sources of government revenue, agricultural exports are sometimes taxed or internal prices are manipulated in such a way that the prices received by farmers are below what they would be without

the tax. This is the case for rice in Thailand, rice and cotton in Egypt, grains and meat in Argentina, and peanuts and certain other crops in Africa.

Monetary and trade policies of a number of developing countries have also discriminated seriously against efficient production by their own agricultural sectors. Persistent and sizeable overvaluations of their foreign exchange rates have artificially lowered the prices received by farmers for agricultural exports. Embargoes and quotas have also been used to channel agricultural output to the domestic market. Brazil has used such policies to implement its attempts to industrialize.

In a number of developing countries, governments consider a low and stable retail price for basic foods--often cereals--to be an important goal of government policy. To meet this goal, the governments control the prices of these commodities in various ways. For example, such policies are followed in Thailand, Egypt, Indonesia, and Sri Lanka. These policies exist because most consumers have low incomes, spend much of their incomes on food, and much of their food expenditures go for cereals. Thus, the cost of basic cereals is important to the welfare of consumers. Food prices also are an important part of the cost of labor. It is feared that if the cost of food were to rise or fluctuate greatly, this would require increases or fluctuations in wages which would be disruptive to economic development in general.

While these policies are understandable with respect to consumers and to wage workers in industry, their impact on the food production capacity and import pattern of the developing countries needs to be carefully evaluated.

Organization of Research

The spread of technology to new areas and the achievement of the potentially great increases in yield will require greater efforts in research and the organization of research by the United States and the developing countries.

The critical need is for organizing linkages between U.S. research institutions and both the international and national research organizations. Research resources need to be directed into two types of organizations.

The first type is made up of international research institutes organized either along commodity lines or by type of climate. These institutes have made a distinguished record in a short time and are now being coordinated by the Consultative Group on International

Agricultural Research, with the World Bank acting as coordinator.

The second type is made up of national research institutions that have experiment stations placed to study local adaptation. The building of productive national research institutions and the training of research workers have proven to be very difficult, but recent history emphasizes the essentiality of this link in the development process. In particular, backing is needed for an effective outreach program that supports research in the developing countries.

RESEARCH NEEDS

The following were identified as the important problems that require research related to the economic, political, and institutional aspects of technology and research for international development.

Rank Order		
		Agricultural Policies
1		Assess the benefits and costs of importing versus domestically producing farm inputs such as fertilizer and machinery.
8	SP	Assess distribution problems of reaching low-income groups in developing countries, e.g., landless laborers in the rural areas or new migrants to urban areas.
10	S	Assess the impact of international commodity agreements on production, consumption, and trade of the developing countries.
10	S	Develop approaches to predicting the effect of policy decisions on production and consumption.
10	S	Evaluate the impact of monetary and trade policies, e.g., overvaluation of foreign exchange rates, export tariffs, or output, employment, and income in agriculture.
13	SP	Analyze price policies for agricultural inputs and outputs and relate these to general economic policies.
13	SP	Assess the benefits and costs of importing versus domestically producing foods including fabricated foods, such as CSM, other food supplements, and infant and weaning foods.

Rank Order		
		Agricultural Policies (continued)
15		Analyze the relationship of nutritional needs, producer prices, and consumer costs to facilitate income transfer within the marketplace.
16	SP	Assess policies affecting the supply and distribution of farm inputs.
17	SP	Analyze the employment and income distribution impacts of output-increasing technologies.
19		Analyze alternative methods to reduce risks in agricultural lending by financial institutions in developing countries.
	S	Analyze the impact of incentive producer prices on the cost of food to urban consumers.
	S	Develop data for the study of consumption patterns of both rural and urban households.
	S	Develop price elasticities for major agricultural products.
	S	Analyze the profitability of "recommended" inputs and practices and investigate other promising ones under farm conditions, giving attention to constraints that limit improved yields.
	S	Investigate and publish price information, especially producer prices, where this is not available.
		Organization of Research
2	SP	Develop a policy, with specific criteria, for the use of U.S. agricultural research resources on the problems of developing countries, OPEC countries, etc.
3	SP	Assess the research resources and organizational requirements in developing countries.
4		Provide a continuing source of research information and work in progress from public and private research organizations to developing country research organizations and relevant government agencies.

Rank Order		
		<u>Organization of Research</u> (continued)
4	SP	Assess and develop mechanisms to facilitate involvement of U.S. institutions through an association of U.S. universities and other food research institutions in order to pool talents and experience and serve as a national resource for research problems overseas.
6		Determine means of improving training in research management.
7	SP	Continue support for and develop methods of expanding the outreach capabilities of the international research centers.
9		Develop and/or emphasize methods to transfer research results through close coordination with local education and extension programs.
18		Determine return to investment in agricultural research in LDC's.
19		Conduct research on organizational and administrative means of avoiding subordination of research to production or service functions.
	S	Strengthen national research institutions.

16.0 BASIC PROBLEMS OF PLANT GROWTH AND REPRODUCTION

Objective: To improve the physical, biochemical, and genetic processes in plants that now limit photosynthetic rates, biosynthesis of ammonia, and genetic control of nutritional quality and yield.

SITUATION

The productivity of the earth depends on two critically important processes unique to the plant kingdom--photosynthesis and the biosynthesis of ammonia. These processes are greatly influenced by the nutritional efficiency of plants, by soils, and by environmental stress. The rate of increase of yields of some of our major food, feed, and fiber crops has slowed and in some crops has plateaued. To break these yield barriers, it will be necessary to make significant fundamental improvements in the photosynthetic, nitrogen fixation, and nutritional capabilities of our major crops.

The use of fertilizers in the future may be limited by cost and the availability of supply. With the major calorie-producing crops of the world so dependent on fertilizers, research to improve the photosynthetic capability and nutritional efficiency of plants, as well as supplemental sources of nitrogen, seems imperative. Symbiotic nitrogen fixation is a natural and promising supplement to fertilizer nitrogen, but its efficiency must be improved greatly.

Crop failures occur every year somewhere in the United States and in many areas of the world because of unpredictable environmental stresses. They vary as to composition, intensity, duration, geographical region of occurrence, and expanse of land area affected. Production methods and improved plant varieties are badly needed to enable farmers to achieve optimum productivity within the limits of these environmental stresses.

Yield potentials of some of the world's major food crops have increased remarkably, but progress has been uneven. Hybridization raised the yield barrier of corn and grain sorghums. Improvements in plant design have been credited for some of the yield increases of wheat and rice. Soybeans and pulses have been more resistant to yield increases on a worldwide basis. This is an important concern because these high-protein crops are needed as future replacements for some of the animal proteins.

Breeding of disease- and insect-resistant varieties has increased the yields of most crops, but the contest is a continuous one as new genetic strains of diseases and insects arise to replace those brought under control. Improved techniques are needed for making crosses between widely different species. Research on cell fusion offers possibilities for combining species that have resisted sexual reproduction techniques. New crop varieties more suitable for multiple cropping will be needed as food requirements increase.

Improvements in plant efficiency also are possible by gaining a better understanding of the biochemical pathways to protein synthesis. Recognition of limiting factors also points out where management practices may be improved to overcome them. Incorporation of genes in cereals to provide better nutritional quality has progressed with only a few crops. Limitations imposed by inadequate instrumentation for screening for quality characteristics are being removed.

RESEARCH NEEDS

The following were identified as the important problems that require research related to basic problems of plant growth and reproduction.

Rank Order		
1		Develop techniques for cell culture, tissue culture, somatic hybridization, and related approaches for basic research in plant physiology and genetics.
2		Determine the basic mechanisms involved in plant growth regulator activity.
3		Develop techniques whereby germplasm of vegetatively propagated plants, particularly fruits, vegetables, and woody shrubs may be maintained.
4		Determine the fundamental mechanisms of photosynthesis in order to improve plant productivity.
5	SP	Improve and develop nitrogen-fixing capacity in nonlegume plants.
6	SP	Devise new methods and improve existing methods of plant breeding.
7	SP	Develop more efficient symbiotic nitrogen-fixing strains of bacteria and reduce or eliminate the inhibition of the nitrogen-fixing enzyme of NH_4.

Rank Order		
7	SP	Identify and develop improved strains of microorganisms capable of nonsymbiotic (associative) nitrogen fixation.
9	SP	Develop techniques to screen for rate of carbon dioxide fixation, superior photosynthetic efficiency in plants, cells, metabolic pathways and enzyme systems and their utilization in crop improvement.
10	SP	Identify protein components of important crops and related wild species; determine amino acid composition of proteins and their nutritional implications; determine mechanisms that control synthesis of protein components and devise procedures for utilizing this knowledge in improving crop species.
11	SP	Determine ways to diminish wasteful respiration in crop plants.
12	SP	Improve genetic potential of plants in nutrient uptake and determine the extent to which absorption, translocation, and accumulation of nutrients restrict production.
13	SP	Devise methods to transfer genes among relatively unrelated types of plants.
14	SP	Develop improved plant efficiency to assimilate, translocate and use products of photosynthesis.
15	SP	Define the interrelationships of seed environment, seed physiology, and seed microbiology as they affect plant growth and crop production.
16	SP	Study plant stresses, devise principles to modify stress, look for genetic and physiological differences in stress tolerance, and use them to develop stress-tolerant varieties.
17		Search for genes in higher plants that enable these organisms to fix atmospheric nitrogen directly.
18	SP	Increase the efficiency of crop plants in using nitrate.
19		Develop new strains of mycorrhizal fungi capable of association with a wide range of plant roots and so to improve the capacity of crops to utilize soil nutrients otherwise unavailable.

Rank
Order

20 SP Determine the extent to which a plant's capacity to synthesize, transport, and accumulate dry matter restricts production.

S Develop pesticides and plant regulators that are both more effective and more environmentally safe.

S Develop improved seed storage methods and technology to maximize viability and seedling vigor.